NOTE

This Microfiche meets the quality requirements of the American National Standard for Microfiche of Documents (ANSI PH5.9-1975). However, because of imperfections in the document from which it was made, it contains images that are illegible or difficult to read. The source document for this microfiche is the best copy that could be obtained prior to filming.

Congressional Information Service, Inc.
4520 East-West Highway
Bethesda, Maryland 20814

CIS

S. Hrg. 101-1080

ALTERNATIVE AGRICULTURE: PERSPECTIVES OF THE NATIONAL ACADEMY OF SCIENCES AND THE COUNCIL FOR AGRICULTURAL SCIENCES AND TECHNOLOGY

HEARING

BEFORE THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

JUNE 6, 1990

Printed for the use of the Joint Economic Committee

U.S. GOVERNMENT PRINTING OFFICE
36-065 WASHINGTON : 1990

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

J841-6.

JOINT ECONOMIC COMMITTEE

[Created pursuant to sec. 5(a) of Public Law 304, 79th Cong.]

HOUSE OF REPRESENTATIVES	SENATE
LEE H. HAMILTON, Indiana, *Chairman*	PAUL S. SARBANES, Maryland, *Vice Chairman*
AUGUSTUS F. HAWKINS, California	LLOYD BENTSEN, Texas
DAVID R. OBEY, Wisconsin	EDWARD M. KENNEDY, Massachusetts
JAMES H. SCHEUER, New York	JEFF BINGAMAN, New Mexico
FORTNEY PETE STARK, California	ALBERT GORE, Jr., Tennessee
STEPHEN J. SOLARZ, New York	RICHARD H. BRYAN, Nevada
CHALMERS P. WYLIE, Ohio	WILLIAM V. ROTH, Jr., Delaware
OLYMPIA J. SNOWE, Maine	STEVE SYMMS, Idaho
HAMILTON FISH, Jr., New York	PETE WILSON, California
FREDERICK S. UPTON, Michigan	CONNIE MACK, Florida

Joseph J. Minarik, *Executive Director*
Richard F Kaufman, *General Counsel*
Stephen Quick, *Chief Economist*
Joe Cobb, *Minority Staff Director*

CONTENTS

WITNESSES AND STATEMENTS

WEDNESDAY, JUNE 6, 1990

Page

Hamilton, Hon. Lee H., chairman of the Joint Economic Committee: Opening statement 1

Symms, Hon. Steve, member of the Joint Economic Committee: Opening statement 2

Miller, Fred P., Ph.D., Department of Agronomy, Ohio State University, and member, Council for Agricultural Science and Technology, accompanied by Virgil W. Hays, Ph.D., Department of Animal Science, University of Kentucky, and member, Council for Agricultural Science and Technology; and Vernon W. Ruttan, Ph.D., Department of Agricultural and Applied Economics, University of Minnesota, and member, Council for Agricultural Science and Technology 85

Pesek, John, Ph.D., Head of the Department of Agronomy, Iowa State University, and chair, Board on Agriculture, National Academy of Sciences Study Committee on Alternative Agriculture, accompanied by Charles Benbrook, Ph.D., executive director, Board on Agriculture, National Academy of Sciences; and Robert Goodman, Ph.D., Calgene, Inc., and member, Board on Agriculture, National Academy of Sciences 285

Lee, Gary A., Ph.D., Idaho Agricultural Experiment Station, University of Idaho 311

SUBMISSIONS FOR THE RECORD

WEDNESDAY, JUNE 6, 1990

Lee, Gary A.: Prepared statement 314

Miller, Fred P.:

- Prepared statement of representatives from the Council for Agricultural Science and Technology 88
- Report entitled "Alternative Agriculture, Scientists' Review" 95

Pesek, John and Robert Goodman: Joint prepared statement 288

Symms, Hon. Steve: Study entitled "Economic Impacts of Reduced Chemical Use" 5

ALTERNATIVE AGRICULTURE: PERSPECTIVES OF THE NATIONAL ACADEMY OF SCIENCES AND THE COUNCIL FOR AGRICULTURAL SCIENCES AND TECHNOLOGY

WEDNESDAY, JUNE 6, 1990

Congress of the United States,
Joint Economic Committee,
Washington, DC.

The committee met, pursuant to notice, at 10:05 a.m., in room 340, Cannon House Office Building, Hon. Lee H. Hamilton (chairman of the committee) presiding.

Present: Representatives Hamilton, Jontz, and English; and Senator Symms.

Also present: David Freshwater and Scott Borgemenke, professional staff members; and Joe Cobb, minority staff director.

OPENING STATEMENT OF REPRESENTATIVE HAMILTON, CHAIRMAN

Representative Hamilton. The Joint Economic Committee will come to order.

The committee is pleased to hold this hearing on the potential role of alternative agriculture. The release of the National Academy of Sciences' (NAS) report on Alternative Agriculture in 1989 stimulated a round of debate over the potential for adjustment by American agriculture. In response to this debate, the Joint Economic Committee requested that the Council for Agricultural Science and Technology (CAST) conduct a review of the study to provide the committee with their perspective on the issue.

This hearing provides an opportunity for the two groups to discuss their reports with the committee. The Joint Economic Committee is pleased that representatives of the NAS Board on Agriculture and the Council for Agricultural Science and Technology can be with us today, and we look forward to a productive hearing.

My understanding is that each group will make a brief opening statement of approximately 5 minutes or so, and then we will move to questions.

Representing the Council for Agricultural Science and Technology are Mr. Fred Miller, from Ohio State University, who contributed to the CAST review; Mr. Virgil Hays, from the University of Kentucky, past president of CAST and contributor to the review; and Mr. Vernon Ruttan, from the University of Minnesota, also a contributor to the CAST review.

Representing the Board on Agriculture are Mr. John Pesek, from Iowa State University, who chaired the study on Alternative Agriculture; Mr. Robert Goodman, from Calgene, Inc., a member of the study group; and Mr. Charles Benbrook, executive director of the Board on Agriculture.

I am very pleased that Senator Symms could join me this morning. We have had a vote called, as I indicated might occur. That means I will turn to Senator Symms for any opening statement he would like to make and then, Senator, after you have finished that statement, we can just begin the hearing, and I will get back within a very few minutes.

We are delighted to have all of you with us. Your prepared statements, of course, will be put into the record in full. And we look forward to the discussion.

Senator Symms, if you will excuse me while I leave.

OPENING STATEMENT OF SENATOR SYMMS

Senator SYMMS [presiding]. Thank you very much, Mr. Chairman. And, Mr. Chairman, before you leave the room, I do want to thank you very much for calling this hearing because I believe this is a very important subject not only for the Congress, but for the American people.

I happen to be one of those who believes that, through our system of private enterprise, and the combination of State and Federal research, the extension system and ag research programs, the private research that has gone on in this country, and the incentive reward system of private landowners trying to farm for their own rewards, we have developed a system of food production that is unmatched in the world. I believe we have the cleanest, the safest, the healthiest, the most abundant, and the most affordable and convenient supply of food of any people living on this Earth. And I want to compliment all of you who make a substantial contribution to that by your life's work in ag research and chemical research. And I think that this hearing can be very helpful.

Before I came to Congress, my formal education was in agriculture at the University of Idaho, with a specific major in horticulture, and have been involved in the produce industry ever since. During that time, I have seen active crop management techniques come and go, and different farm chemicals come into use, and then pass away. But I never, ever once observed an agricultural chemical that was used because some farmer wanted to sink a few more dollars into the field or into the orchard. In fact, the name of the game is to produce a crop while sinking as little cash into the production of the crop as possible.

How well I remember in the early 1960's when the coddling moth, as it has always been a problem in the apple industry, required the use of a product that we were using then—it was guthion—to control coddling moth, and we discovered that if we used too much of it, it is true it would clean out the coddling moth, but it killed all the predator mites. And then we had to come back and spray the trees with miticide again, and it was all very costly.

So, we continued to reduce the amount of product used to control coddling moth until today in most of the major producing areas, you will now find occasionally an apple that has been stung by a coddling moth, which is something during the 1950's and 1960's you could not find in most of the producing orchards. Now you can find a few because of the partial integrated control that the growers apply, using the minimum of chemicals necessary to control coddling moth so they do not destroy the predator mites. Those mites then eat the mites that damage the trees and keep them from producing apples.

Those are the kinds of things that I have seen happen in modern agriculture technology, that have been developed specifically to meet the demands of the people. Farmers and producers generally employ the methods they use today in order to make quality agriculture products available at a reasonable price.

Has this conventional agriculture, as dubbed by the Alternative Agriculture report, failed at achieving those goals? There is no evidence in my view that it has failed. The American consumer, as I said at the outset, has access to a food supply that is the marvel of the world. When President Gorbachev visited Minneapolis recently, and during earlier visits here in Washington, what is it we proudly displayed? Our supermarkets filled with a multitude of low-priced, nutritious fruits and vegetables and other foods.

Alternative agriculture is certainly not made vindicated by the dismal failure of conventional agriculture. Conventional agriculture has been a success. What worries me, however, is the way that some do justify alternative agriculture. They cite the fact that chemicals are artificial, man made, and not natural. Using this assertion, they then advance the pseudotheology that this, in and of itself, makes them bad.

A chemical is merely a name we give to substances which react in certain identifiable ways. The nitrogen and oxygen we breathe, as well as the proteins that build our cells, are all chemicals. Pesticides are not made harmful merely by being chemicals, although that perception is held by many.

In fact, mother nature makes more pesticides and herbicides than do humans. Plants produce their own pesticides, many of which are more harmful than the manmade alternatives.

Let me give you an example of some natural chemicals at work. Tropical leaf-cutter ants produce in their bodies a very potent fungicide; and the ant colonies harvest and store a compost of leaves which they then coat with this chemical. The fungicide acts as a deadly poison to nearly every species of fungus, but one. This one surviving fungus just happens to be the food of preference for the colony, which they then cultivate on the mulch of leaves. The cultivation is much easier because the fungus does not have to compete with any other undesirable fungi because of the ant's chemical secretion.

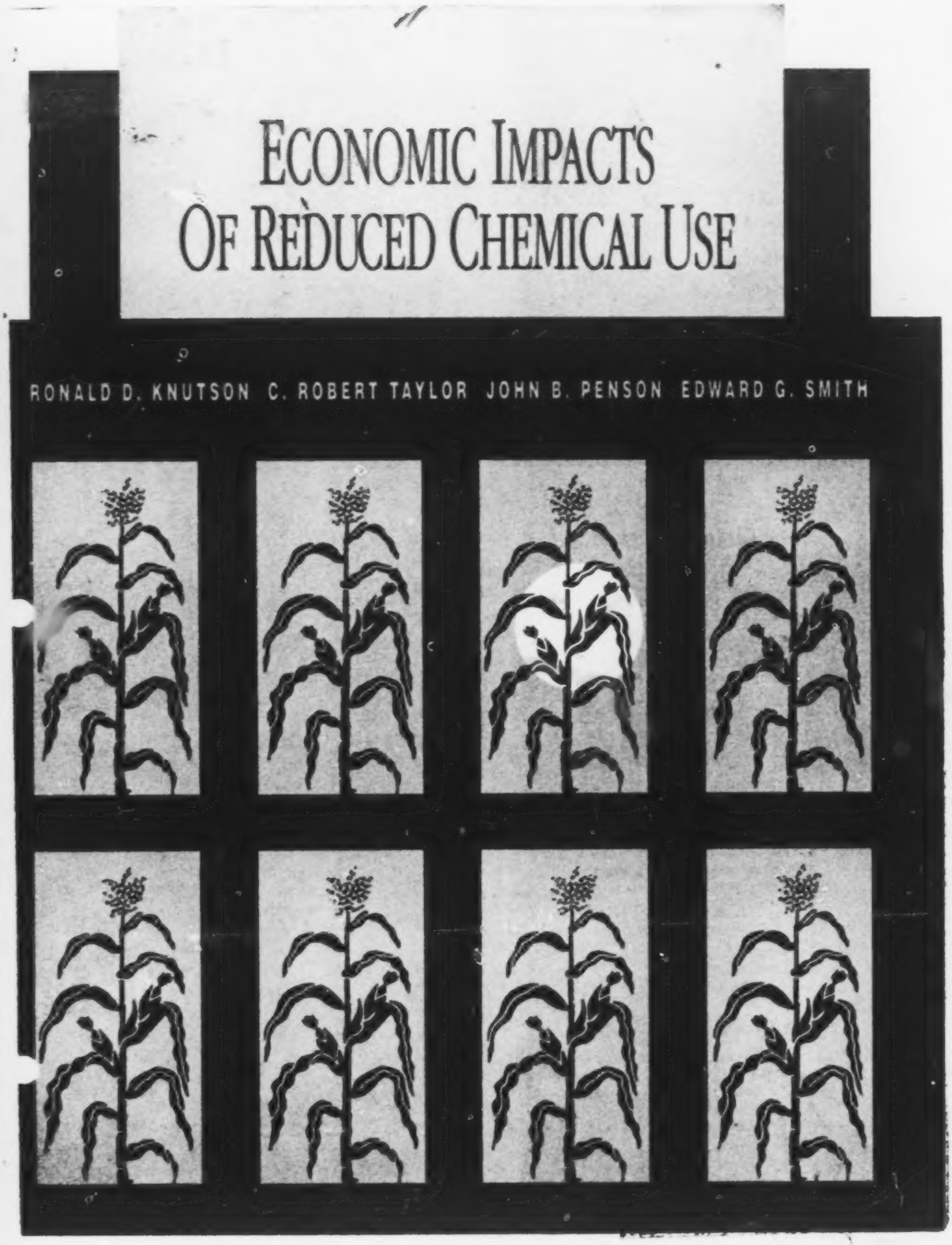
Now, look how closely this parallels exactly with what farms do in Idaho and other States using agricultural chemicals to promote a better, more plentiful crop of food. It is not unnatural. It is just using our native human intelligence to increase and improve our food supply. If an ant can do it, and that is natural, why then if humans do it, is it considered unnatural?

My fear is that an irrational policy of denying technology to ourselves would come with dire consequences for both the farmers and consumers. And I would ask, Mr. Chairman and members of the committee, that a study on the Economic Impacts of Reduced Chemical Use, prepared by Knutson & Associates, a research firm in College Station, TX, be added to the hearing record following my remarks. That study indicates that a reduction in chemical use could result in a 12-percent increase in the weekly food bills for the average American family, as well as a 50-percent reduction in foreign grain and cotton sales, and a 10-percent increase in soil erosion.

Now, these results are dramatic, Mr. Chairman. They certainly tell us that there is a lot at stake in this debate. And that is why I am very appreciative of the work of the Council for Agricultural Science and Technology in trying to promote rational scientific thought with regard to agricultural chemical use and the advisability of alternatives to that use. The professional and scientific way in which they approach the issue is very constructive. When CAST points out that certain incentives under government programs do, in fact, encourage maximum yields, rather than most efficient yields, that information is very valuable to the debate. Certainly any policy change that encourages farmers to produce more cost effectively is good for the farmer, good for the consumer, and may indeed yield benefits to the environment as well.

But for us to look forward to some day when we view that subsistence agriculture somehow is better than the method we have been trying to pursue, I think it should bring a concern to all of us.

[The report referred to by Senator Symms follows:]



ECONOMIC IMPACTS OF REDUCED CHEMICAL USE

RONALD D. KNUTSON C. ROBERT TAYLOR JOHN B. PENSON EDWARD G. SMITH

Project Director
Ronald D. Knutson

Project Sponsors
Tennessee Valley Authority
American Farm Bureau Federation
American Soybean Association
Riceland Foods, Inc.
Dow Elanco
Monsanto Co.
ConAgra, Inc.
R.J. Reynolds Tobacco Co.
IMC Fertilizer, Inc.

Correspondence regarding this study or the data base publication supporting it should be sent to Ronald D. Knutson, Knutson & Associates, 1011 Rose Circle, College Station, TX 77840.

7

ECONOMIC IMPACTS OF REDUCED CHEMICAL USE

Ronald D. Knutson
C. Robert Taylor
John B. Penson
Edward G. Smith

Copyright © 1990 by Knutson & Associates

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording or any information storage and retrieval system now known or to be invented, without permission in writing from the publisher, except by a reviewer or researcher who wishes to quote brief passages in connection with a review or reference written for inclusion in a magazine, newspaper, broadcast or research publication.

Published in 1990 in the United States of America by Knutson & Associates, 1011 Rose Circle, College Station, Texas 77840.

PREFACE

Questions over the merits of chemically based agricultural inputs have become more numerous and widespread during the past two decades. Most of the recent discussion has concerned the impacts of these technologies on the environment. Little attention has been given, however, to the contributions these technologies have made toward lowering food costs, maintaining exports of agricultural products, and ensuring the security of food supply. Everyone has an interest in these issues -- farmers, agribusiness management and employees, and consumers.

As a result of concern for these important issues, a consortium of public and private agricultural interests initiated this study. The Tennessee Valley Authority (TVA) cooperated with the Texas A&M University System to represent public sector interests by developing the data base for the study. Private sector representation on the consortium included the American Farm Bureau Federation; the American Soybean Association; Riceland Foods, Inc.; Dow Elanco; Monsanto Co.; ConAgra, Inc.; R.J. Reynolds Tobacco Co.; and IMC Fertilizer, Inc. Financing for the project was provided in the following proportions: public institutions, 40 percent; producer organizations, 23 percent; pesticide manufacturers, 18 percent; food companies, ten percent; and fertilizer manufacturers, nine percent. The steering committee for the project included John Hosemann, American Farm Bureau Federation; David Asbridge, American Soybean Association; Dick Gady, ConAgra; Tom Elam, Dow Elanco; and Tom Foster, Tennessee Valley Authority.

The authors of this report are professors of agricultural economics at their respective institutions. Ronald D. Knutson is Director of the Agricultural and Food Policy Center at Texas A&M University. C. Robert Taylor is the Alfa Eminent Scholar in Agriculture and Public Policy at Auburn University. John B. Penson is the Stiles Professor of Agricultural Finance at Texas A&M University. Edward G. Smith is the Distinguished Roy B. Davis Professor for Agricultural Cooperation at Texas A&M University.

The results of the study are reported in three publications:

- An executive summary.
- A data base report supported by TVA and titled *Impacts of Chemical Use Reduction on Crop Yields and Costs.*
- An overall study report titled Economic Impacts of Reduced Chemical Use.

Correspondence regarding this study or the data base publication should be sent to Ronald D. Knutson, 1011 Rose Circle, College Station, Texas 77840.

TABLE OF CONTENTS

Executive Summary 1

Objectives and Procedures 1
Consumer and Food Price Inflation 2
Trade 2
Food Security and the Environment 4
Crop Versus Livestock Producer 5
South Versus North 5
Lower Yields, Higher Unit Costs 5
Implications 6

Chapter One:
Background, Objectives, and Procedures 7

Problem 7
Objectives 7
Chemical Use Scenarios 8
Selection of Commodities 8
Procedure 8
Policy Assumptions 10
Procedural Summary 11

Chapter Two:
Initial Crop Sector Impacts 12

Overview of Results 12
Corn 14
Soybeans 14
Wheat 14
Cotton 14
Peanuts 17
Rice 17
Sorghum 17
Barley 17
Conclusions 18

Chapter Three:
Production, Price, and Utilization Impacts 19

Chemical Use Reduction Scenarios 19
Crop Sector Impacts 20
Livestock, Dairy, and Poultry Sector Impacts 25

Chapter Four:
Agriculture Sector and Macroeconomic Impacts 32

Macroeconomic Environment 32
Macroeconomic Impacts 33
Agriculture Sector Impacts 33
Agribusiness Impacts 37
Rural and Urban Impacts 41
Inflation and Consumer Impacts 41
Increased Household Food Expenditures 42

Chapter Five:
Summary, Conclusions, and Implications 42

Appendices 45

LIST OF FIGURES, TABLES

FIGURES PAGE

S-1 Annual Food Expenditures Per Household by Chemical Use Scenario, 1995-98 3
S-2 Percentage Change in the Consumer Price Index for Food and Beverages by Chemical Use Reduction Scenario, 1987-94 3
S-3 Net Exports of Major Grains, 1995-98 Average 3
S-4 Year-Ending Stocks of Major Grains, 1994-98 Average 4
S-5 Real Net Farm Income for Crop and Livestock Producers, 1995-98 4
S-6 Regional Yield Reduction Associated With No Chemical Use by Commodity 5

1 U.S. Percentage Reduction in Corn Yield/Acre by Chemical Use Reduction Scenario 15
2 U.S. Percentage Reduction in Soybean Yield/Acre by Chemical Use Reduction Scenario 15
3 U.S. Percentage Reduction in Wheat Yield/Acre by Chemical Use Reduction Scenario 15
4 U.S. Percentage Reduction in Cotton Yield/Acre by Chemical Use Reduction Scenario 16
5 U.S. Percentage Reduction in Peanut Yield/Acre by Chemical Use Reduction Scenario 16
6 U.S. Percentage Reduction in Rice Yield/Acre by Chemical Use Reduction Scenario 16
7 U.S. Percentage Reduction in Sorghum Yield/Acre by Chemical Use Reduction Scenario 17
8 U.S. Percentage Reduction in Barley Yield/Acre by Chemical Use Reduction Scenario 18
9 U.S. Corn Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 20
10 U.S. Corn Production by Chemical Use Reduction Scenario, 1995-98 20
11 U.S. Corn Prices by Chemical Use Reduction Scenario, 1995-98 20
12 U.S. Corn Utilization by Chemical Use Reduction Scenario, 1995-98 20
13 U.S. Soybean Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 21
14 U.S. Soybean Production by Chemical Use Reduction Scenario, 1995-98 21
15 U.S. Soybean Prices by Chemical Use Reduction Scenario, 1995-98 21
16 U.S. Soybean Utilization by Chemical Use Reduction Scenario, 1995-98 21
17 U.S. Wheat Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 22
18 U.S. Wheat Production by Chemical Use Reduction Scenario, 1995-98 22
19 U.S. Wheat Prices by Chemical Use Reduction Scenario, 1995-98 22
20 U.S. Wheat Utilization by Chemical Use Reduction Scenario, 1995-98 22
21 U.S. Cotton Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 23
22 U.S. Cotton Production by Chemical Use Reduction Scenario, 1995-98 23
23 U.S. Cotton Prices by Chemical Use Reduction Scenario, 1995-98 23
24 U.S. Cotton Utilization by Chemical Use Reduction Scenario, 1995-98 23
25 U.S. Peanut Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1994 24

26 U.S. Peanut Production by Chemical Use Reduction Scenario, 1994 24
27 U.S. Peanut Prices by Chemical Use Reduction Scenario, 1994 24
28 U.S. Peanut Utilization by Chemical Use Reduction Scenario, 1994 24
29 U.S. Rice Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 25
30 U.S. Rice Production by Chemical Use Reduction Scenario, 1995-98 25
31 U.S. Rice Prices by Chemical Use Reduction Scenario, 1995-98 25
32 U.S. Rice Utilization by Chemical Use Reduction Scenario, 1995-98 25
33 U.S. Sorghum Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 26
34 U.S. Sorghum Production by Chemical Use Reduction Scenario, 1995-98 26
35 U.S. Sorghum Prices by Chemical Use Reduction Scenario, 1995-98 26
36 U.S. Sorghum Utilization by Chemical Use Reduction Scenario, 1995-98 26
37 U.S. Barley Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98 27
38 U.S. Barley Production by Chemical Use Reduction Scenario, 1995-98 27
39 U.S. Barley Prices by Chemical Use Reduction Scenario, 1995-98 27
40 U.S. Barley Utilization by Chemical Use Reduction Scenario, 1995-98 27
41 U.S. Broiler Production by Chemical Use Reduction Scenario, 1995-98 Average 28
42 U.S. Broiler Price - 12 City Average - by Chemical Use Reduction Scenario, 1995-98 Average 28
43 Broiler Consumption Per Capita by Chemical Use Reduction Scenario, 1995-98 Average 28
44 U.S. Processed Pork Production by Chemical Use Reduction Scenario, 1995-98 Average 28
45 U.S. Farm Prices for Hogs by Chemical Use Reduction Scenario, 1995-98 Average 28
46 U.S. Pork Consumption Per Capita by Chemical Use Reduction Scenario, 1995-98 28
47 U.S. Beef Slaughter by Chemical Use Reduction Scenario, 1989-1998 29
48 U.S. Beef Slaughter by Chemical Use Reduction Scenario, 1995-98 Average 29
49 U.S. Price of Beef by Chemical Use Reduction Scenario, 1995-98 Average 29
50 U.S. Beef Consumption Per Capita by Chemical Use Reduction Scenario, 1995-98 Average 29
51 U.S. Milk Output Per Cow by Chemical Use Reduction Scenario, 1991-98 30
52 U.S. Beginning Inventory of Milk Cows, 1991-98 30
53 U.S. Milk Production by Chemical Use Reduction Scenario, 1995-98 Average 30
54 U.S. Milk Price by Chemical Use Reduction Scenario, 1995-98 Average 30
55 U.S. Milk Consumption Per Capita, 1995-98 Average 31
56 Real Net Farm Income for Crop and Livestock Producers, 1995-98 36
57 Farm Production Regions 36
58 Chemical Use Reduction Gains and Losses in Billion Dollars by the Purchased Input Agribusiness Sector, No Chemical Scenario, 1994 (1994 Dollars) 37
59 Chemical Use Reduction Gains and Losses in Billion Dollars by the Purchased Input Agribusiness Sector, No Pesticides Scenario, 1994 (1994 Dollars) 37
60 Net Exports of Major Grains, 1995-98 Average 39
61 Net Exports of Cotton, 1995-98 Average 39
62 Year-Ending Stocks of Major Grains, 1995-98 Average 40
63 Percentage Change in the Consumer Price Index for Food and Beverages by Chemical Use Scenario, 1987-1994 40
64 Annual Food Expenditures Per Household by Chemical Use Reduction Scenario, 1995-98 40

TABLES PAGE

1 National Percentage Yield Reduction, Range of Regional Percentage Reduced Yields, and Total Economic Cost/Unit for the No Chemicals Option 13
2 Regional Cropping Patterns for Selected Farm Program Crops, Acres Planted, 1994 34
3 Regional Gross Receipts and Net Income From Eight Crops, 1994 Dollars 35

EXECUTIVE SUMMARY

Economic Impacts Of Reduced Chemical Use

If chemical use in production agriculture were substantially curtailed, the economic impacts to the nation would extend from farmers and their input suppliers to the overall economy and consumers. This study analyzes the U.S. economic impacts of chemical use reduction and focuses on the following major conclusions:

- In terms of 1989 dollars, consumers would spend $228 more per household annually if pesticide use were eliminated. If the chemical ban were extended to include inorganic nitrogen fertilizer, expenditures would increase by $428 each year. For the middle income consumer, this amounts to a 12 percent increase in the consumer's weekly food bill. Low income consumers would be spending 44 percent of their income on food.
- Without the availability of chemicals, the annual rate of increase in food prices during 1995-98 would reach the double digit levels that existed during the world food crisis of the early 1970s when price controls and export embargoes were imposed to stem inflation.
- Removing pesticides and inorganic nitrogen fertilizer (no chemicals) would drop the volume of exported grain and cotton by nearly 50 percent.
- Banning chemicals would lead to a 10 percent increase in cultivated acreage and an associated rise in erosion.
- Crop producers would experience gains in income, but livestock producer income would drop by an amount that would nearly offset the gain to crop producers.
- Crop production in Southern states would fall more sharply than in Northern states. This would be due to larger reductions in yields as a result of climates more favorable to pests and soils more deficient in nitrogen and other nutrients.
- Crop yields would fall sufficiently to result in higher unit costs of production.

Objectives and Procedure

These conclusions were based on a study that involved the input of more than 140 agricultural scientists. These scientists provided information for estimating the impacts of substantially reduced chemical use on crop yields and costs. The crops selected for analysis include corn, soybeans, wheat, barley, cotton, rice, peanuts and sorghum. The study concentrates on these commodities because they account for more than 75 percent of the agricultural pesticides applied to crops throughout the nation and more than 70 percent of the inorganic nitrogen fertilizer used in U.S. agriculture.

The seven chemical use reduction scenarios analyzed in this study include no herbicides, no insecticides and fungicides (except seed treatments), no inorganic nitrogen fertilizer, and various combinations thereof (including no pesticides and no chemicals). For the purposes of this study, the no pesticides scenario refers to the use of no insecticides, herbicides or fungicides with the exception of seed treatments. The no chemicals scenario refers to the use of no pesticides (as defined above) and no inorganic nitrogen fertilizer.

Ideally, the study would have estimated the economic impacts of partial restrictions on use of pesticides as well as the impacts of complete bans. However, the zero option was an essential, logical and manageable starting point for scientific inquiry on this topic. Research involving partial restrictions is necessary, but it is very difficult to identify a limited number of partial restrictions relevant to the current policy debate because of the very large number of individual pesticides and ways of implementing partial restrictions. Therefore, this study takes the essential first step of analyzing complete bans of broad groups of chemicals. The zero option establishes bounds on the effects of less severe regulations. Of course, partial bans would be expected to have less economic impact compared to the effects given in this report; however, the magnitude of those effects requires further research. The results of this study combined with other scientific partial reduction studies would provide the basis for informed public policy decisions on reduced chemical use.

> “*Food price inflation resulting from no chemical use would exceed 10 percent annually and approach the 14.5 percent level that existed during the world food crisis in 1973 and 1974.*”

Yield estimates associated with each of the seven chemical use reduction scenarios were obtained from leading U.S. land-grant university plant scientists. In making their estimates, these scientists made appropriate adjustments in crop rotation patterns, the use of green manure, increased cultivation, and so forth. Farm management economists converted the yield estimates and management practice changes specified by the crop scientists into per acre costs of production. The baseline for the analysis involved conventional farming practices that included pesticide and fertilizer use as quantified in the ERS/USDA *Cost of Production, 1987* survey. Each scenario was analyzed utilizing AG-GEM, a computerized agricultural-macroeconomic simulation model. Rice and peanuts were analyzed independent of the AG-GEM model. Each analysis, with the exception of rice and peanuts, evaluated the impacts on regional crop production, crop and livestock prices, consumption and utilization, agribusiness sales, food prices, and overall macroeconomic activity. Rice and peanut price impacts were estimated only for the United States in general.

Consumer and Food Price Inflation

Substantially reduced yields and production associated with the chemical use reduction scenarios would drive up farm prices and result in higher food prices and expenditures. As indicated in Figure 1, in terms of 1989 dollars, the average American household of 2.5 persons would spend an additional $228 annually on food from 1995-98 if pesticides were not used. If inorganic nitrogen fertilizer were also restricted, the increased cost per household would be $428 annually. These increases reflect the costs of internalizing perceived societal concerns about the impacts of chemicals on the environment. As a result of the increase in food costs, 20 percent of the U.S. population having the lowest incomes would spend 44 percent of their disposable income on food as compared to the 38 percent they spend today.

For the four-year transition from 1991 through 1994, food price inflation resulting from no chemical use would exceed 10 percent annually and approach the 14.5 percent level that existed during the world food crisis in 1973 and 1974 (Figure 2). To control inflation during that crisis, the United States imposed price controls and export embargoes. Using a no chemical scenario for 1991 through 1994, the study showed that the overall inflation rate for the general economy would increase by nearly two-thirds from that projected in the current practices baseline.

Trade

Under reduced chemical use policies, a decrease in yields and resulting higher prices would substantially reduce the U.S. competitive position in world trade for major grains, cotton and peanuts. As a result, it was necessary to assume that import protection would have to be provided to assure safe food and provide a more level competitive position for U.S. agriculture.

The analysis revealed that higher domestic crop prices would result in sharply reduced exports as the aggregate volume of exported corn, wheat and soybeans declined by 27 percent with no pesticides and nearly 50 percent with no chemicals (Figure 3). These estimates are conservative in that they do not consider that higher market prices and reduced U.S. exports will encourage a supply response from farmers located in other countries. In a separate partial analysis, the reduced export volume was estimated to result in an anticipated loss of 132,000 jobs as a consequence of no pesticide use and 217,000 jobs with no chemical use.

Figure S-1

Annual Food Expenditures Per Household by Chemical Use Scenario, 1995-98

Real Prices 1989 = 100

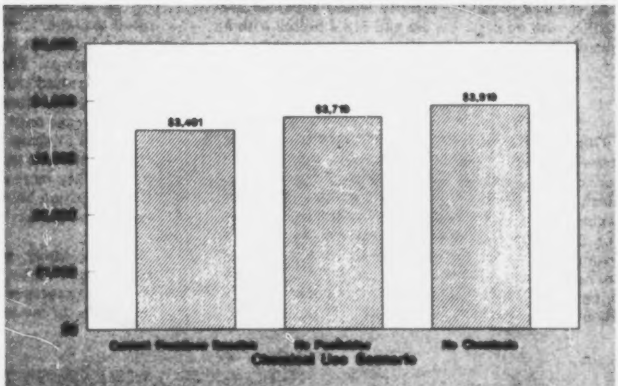


Figure S-2

Percentage Change in the Consumer Price Index for Food and Beverages by Chemical Use Reduction Scenario, 1987-94

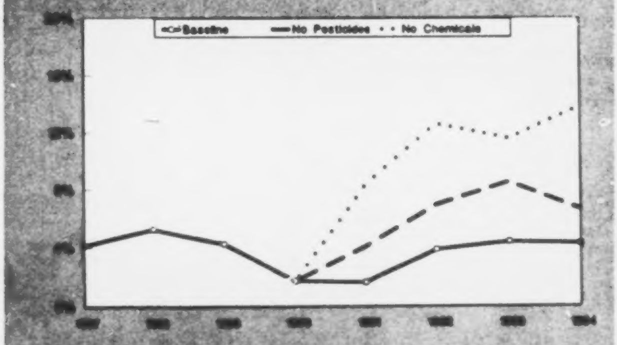
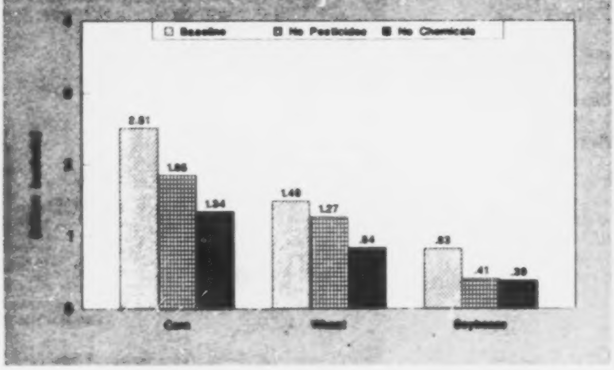


Figure S-3

Net Exports of Major Grains, 1995-98 Average



The reduced economic activity would approach $9.4 billion with no pesticide use and $14.4 billion with no chemical use.

Food Security and the Environment

Except during the world food crisis of the early 1970s, an adequate supply of food in the United States has for the most part been taken for granted. The reduced chemical use scenarios were found to reduce stock levels so much that stock holding minimums would have to be specified, suggesting the potential for extreme price volatility with risk of imposing export restraints. The quantity of corn, wheat and soybeans in storage would decline by 80 percent without chemicals (Figure 4). Wheat stocks would be about 60 percent of baseline levels.

In addition, withholding chemical use would result in higher land prices because land would become a more important input and crop producer net income would increase. The sharp decline in stocks combined with increased land prices would put additional pressure on the use and availability of cropland. Land in the acreage reduction program would be drawn out as a result of sharp increases in crop prices. As early as 1994, nominal land values would rise by 11 percent with further increases indicated through most of the 1990s. Current holders of land would benefit but new entrants would have to pay higher fixed land costs.

With lower production, lower stocks, lower exports, and higher prices, the willingness and ability of U.S. taxpayers and consumers to respond to overseas food security needs would be in serious doubt.

Figure S-4

Year-Ending Stocks of Major Grains, 1994-98 Average

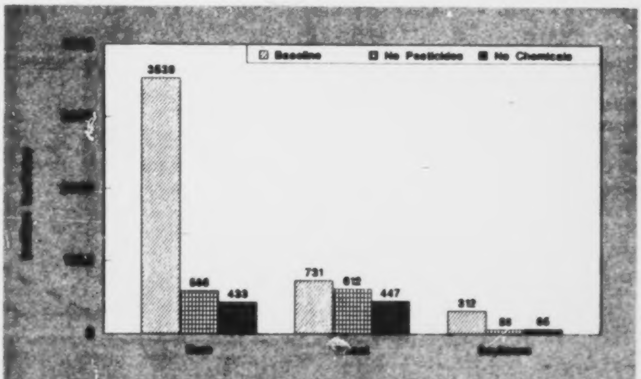


Figure S-5

Real Net Farm Income for Crop and Livestock Producers, 1995-98

Real Prices 1989 = 100

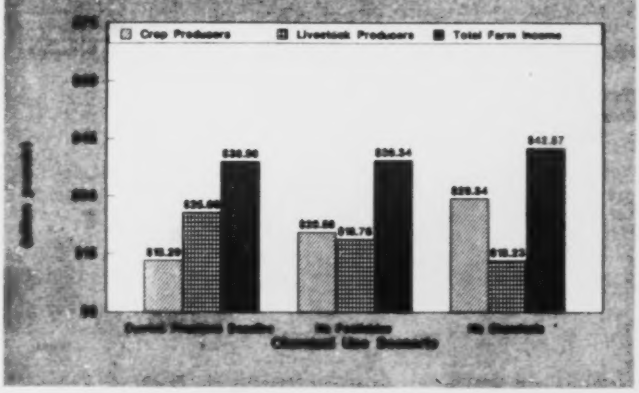
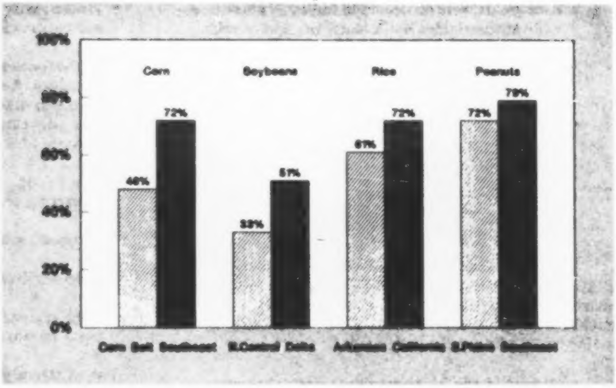


Figure S-6

Regional Yield Reduction Associated With No Chemical Use by Commodity



Lower stocks, higher crop prices, higher land values, and the removal of land from acreage adjustment programs suggest more intensive farming and soil erosion. Consequently, reduced chemical use does not necessarily mean an improved overall environment. Due to a 10 percent expansion of cultivated acres, gross erosion would increase. Most of the increased acreage would come from currently retired land under farm programs.

Crop Versus Livestock Producer

Another trade-off associated with chemical use reduction involves crop and livestock producers. Crop producers would benefit from the higher prices caused by reduced yields and production. For the period 1995-98, crop producer income would more than double in terms of 1989 dollars from $13 billion to $29 billion (Figure 5). Most of this increase in income eventually would be bid into the price of land because it would be the most limiting factor in food production. However, livestock producer income would decrease by 50 percent from $26 billion to $13 billion. The result is a relatively small net gain of $3.6 billion. Recovery from the shocks of higher feed prices would occur in the beef industry even beyond 1998, the last year of the study.

South Versus North

Since the climate and rainfall of the Southern states tend to be more conducive to the growth of weeds, insects, and fungi, eliminating pesticides would decrease yields for most crops more sharply in the South than in the North. This problem would be compounded by the fact that Southern soils tend to have greater need for nitrogen fertilizer and other nutrients. Figure 6 illustrates the impact of these conditions on corn, soybean, rice, and peanut production. Wheat appears to be an exception to this South versus North regional conclusion. The greatest wheat yield impact due to no chemicals would occur in the Pacific Northwest with a 58 percent reduction.

Lower Yields, Higher Unit Costs

It is often implied that reduced chemical use would lower costs. On a per acre basis, however, costs generally fell as chemicals were withdrawn, and yields fell even more. As a result, costs per unit rose as follows:

- U.S. corn yields were projected to fall 32 percent with no pesticides and 53 percent with no chemicals. In response, total costs per bushel would rise by 27 percent with no pesticides and 61 percent with no chemicals.
- Soybean yields were projected to drop by 37 percent with no pesticides and no chemicals while unit costs would increase by 45 percent.
- U.S. wheat yields were projected to decline by 24 percent with no pesticides and 38 percent with no chemicals while unit costs would increase by 33 percent and 50 percent, respectively.
- Cotton yields were projected to drop by 39 percent with no pesticides and 62 percent with no chemicals while total unit costs would rise by 54 percent and 118 percent, respectively.

- Rice yields were projected to fall by 57 percent with no pesticides while costs per cwt would double. With no chemicals, the rice yield would decline by 63 percent and the cost would increase by 133 percent.

- Peanut yields were projected to plummet 78 percent with no pesticides and no chemicals while costs per pound would more than triple.

Implications

The main implication of this study is that pursuit of reduced chemical use policy involves a number of economic, social, real, and perceived trade-offs. The issues are complex and the stakes are high. Among the major trade-offs are the following:

- Perceived and/or real environmental concerns vs. the potential for significant economic impacts on the U.S. economy and the food and fiber industry (e.g., increased costs, reduced competitiveness, increased risk).

- Protectionist policies spawned by reduced competitiveness vs. an open trade policy.

- Higher production costs for U.S. farmers forced to reduce chemical use vs. greater chemical use abroad as other countries increase production to take advantage of higher U.S. crop prices and reduced U.S. exports.

- Low food cost vs. increased food costs impacting on the poor.

- Increased soil erosion vs. reduced chemical use.

- Crop vs. livestock producers.

- Cold regions less favorable to the growth of pests vs. warm and humid regions.

The existence of these trade-offs suggests a need for more information before making further policy decisions regarding chemical use reduction.

CHAPTER ONE

BACKGROUND, OBJECTIVES, AND PROCEDURES

American agriculture has become the envy of the world in terms of its ability to produce an adequate food supply at reasonable cost to the consumer. This position of world leadership was built on a system that encouraged the creation and adoption of technology. Agricultural scientists in the public and private sectors have created technologies that have been developed and distributed by the private sector. Extension specialists have cooperated with private firms to utilize these products in result demonstrations designed to educate farmers on the comparative merits of alternative inputs into the production process. The interaction of public agricultural research and extension with private sector research and development has been a primary factor in the increased productivity of American agriculture.[1] It has allowed progressive and competitive farmers to more than double their output since the 1940s with little change in the quantity of inputs. During much of this time period, these increases of productivity have been accomplished while holding more than 15 percent of the least productive and most erosive cropland out of production.

Problem

An integral component of technological change in agriculture has involved increased utilization of agricultural chemicals. An elaborate regulating system involving the Environmental Protection Agency, the Food and Drug Administration, the U.S. Department of Agriculture, and other related state agencies has been established to test the safety of chemicals, license their use, and train and regulate applicators. Many chemicals have been banned. Yet questions regarding the merits of chemical use continue to arise with implications that substantial and widespread reduction in chemical use could be accomplished without yield reduction or adverse economic impacts.

Objectives

Many questions have been raised concerning the need for a scientific re-evaluation of the impacts of the use of agricultural chemicals on the economic well-being of the U.S. food and fiber industry as well as on consumers here and abroad. This study takes a first step in addressing the economic impacts of reduced chemical use.

The primary objective of this study was to determine the impact of substantially curtailed chemical use on the economic status of producers, on the agribusiness infrastructure, and on consumers. Specific objectives included:

- To evaluate the impacts of reduced agricultural chemical use on the production (yields, acres and costs) of the major farm program crops.

- To evaluate the impacts of reduced production on the prices of the crops studied and, in turn, on the prices and supplies of livestock and poultry.

---

[1] Vernon Ruttan, *Agricultural Research Policy* (Minneapolis: University of Minnesota Press, 1982.)

- To evaluate the impacts of reduced chemical use on producer income, agribusiness, food costs, inflation, and export demand.

- To suggest policy implications.

Chemical Use Scenarios

The point of departure or benchmark for this analysis was the current production practices and chemical use by average commercial farm operations as reported in the Economic Research Service (ERS)/USDA *Cost of Production, 1987*. Utilizing the ERS data as a benchmark, seven chemical use reduction scenarios were analyzed:

- No herbicides (NO H)

- No insecticides or fungicides (except seed treatments) (NO I&F)

- No inorganic nitrogen fertilizer (NO N)

- No herbicides, insecticides, or fungicides (NO H, I&F)

- No herbicides or inorganic nitrogen fertilizer (NO H&N)

- No insecticides, fungicides, or inorganic nitrogen fertilizer (NO I&F, N)

- No herbicides, insecticides, fungicides, or inorganic nitrogen fertilizer (NO CHEM)

The abbreviation after each scenario will be used in the figures and tables throughout this manuscript. The no herbicide, insecticide or fungicide (NO H, I&F) scenario is also referred to in the manuscript as no pesticide. Adding no inorganic nitrogen fertilizer to no pesticides gives the last scenario which is hereinafter referred to as no chemicals (NO CHEM).

Ideally, the study would have estimated the economic impacts of partial restrictions on use of pesticides as well as the impacts of complete bans. However, the zero option was a logical and manageable starting point for scientific inquiry on this topic. Research on partial restriction of chemical use is obviously necessary, but it is very difficult to identify a limited number of partial restrictions relevant to the current policy debate because of the very large number of individual pesticides and ways of implementing partial restrictions. In addition, individual pesticides cannot be considered in isolation. There is an unmanageable number of combinations that would result from partial restrictions and bans on individual chemicals. Therefore, the study focuses on complete bans of broad groups of chemicals. The purpose of analyzing the zero option was to establish bounds on the effects of less severe regulations. Of course, partial bans would be expected to have less economic impact compared to the effects given in this report; however, the magnitude of those effects requires further research.

In summary, this study is designed as a scientifically based starting point or baseline for further analysis. The study does not attempt to weigh the benefits/costs associated with contemporary environment perceptions and concerns. It does provide a point of departure from which further research emphasizing the impacts of marginal reductions in chemical use can proceed. Ultimately, these studies and the quantification of costs and benefits will need to be undertaken -- hopefully before the policy decisions are made.

Selection of Commodities

The commodities analyzed in this study include corn, soybeans, wheat, cotton, rice, peanuts, sorghum and barley. These commodities are major determinants of the economic health of American agriculture. They account for nearly 65 percent of the value and more than 90 percent of the volume of agricultural exports and, therefore, have major impacts on farm prices and incomes as well as on the U.S. balance of trade. In addition to being significant consumption goods, these commodities are major inputs used in both domestic and foreign markets for production of red meat and poultry.

> “*The major crops included here are estimated to account for more than 75 percent of the pesticides used on farms and more than 70 percent of the nitrogen fertilizer used in U.S. agriculture.*”

From a chemical perspective, these major crops are estimated to account for more than 75 percent of the pesticides used on farms and more than 70 percent of the nitrogen fertilizer used in U.S. agriculture.

Procedure

The results of this project were dependent on the ability to obtain objective estimates of the impacts of each of the chemical use reduction scenarios on crop yields. This is primarily an agronomic issue. As a result, leading plant scientists at land-grant universities were relied upon for these data. A leading scientist was chosen from the land-grant university in a major producing state for each of the crops studied. For wheat and barley, duplicate estimates were obtained due to widely differing product characteristics and as a check on potential variability in results from different scientists.

The scientists selected were asked to provide estimates of the yield reduction for each of the chemical use alternatives in each crop producing region. The ERS/USDA *Cost of Production, 1987* was used as the baseline (point of departure) for the crop scientists' yield estimates. The lead crop scientists were urged to rely on all available studies and/or additional crop scientists in making their estimates for each producing region. In formulating the yield impacts, the lead crop scientists were asked to consider the potential for changes in cultural practices such as crop rotation, green manure, increased mechanical cultivation and/or hand labor. The scientists responded by supplying a report that included the estimated yields for each chemical use scenario by crop production region, related cultural practices, and specific sources of information utilized. The citations of the leading scientists indicate that the research results and/or expertise of more than 140 crop scientists were utilized in the study (Appendix A).

Working with the lead crop scientist, a lead agricultural economist with expertise in farm management provided estimates of changes in variable costs of production.[2] The baseline for these estimates was once again the ERS/USDA *Cost of Production, 1987*.

Once received, these estimates were reviewed by Professor Ron Lacewell, a Texas A&M University production economist who previously had been involved in studies of this type. The primary purpose of this review was to obtain consistency among the estimates in both the chemical use scenarios and the production regions. Where inconsistencies were perceived, the lead plant scientist and/or agricultural economist were contacted to provide a justification and/or a revised impact estimate.

While the yield estimates were being quantified, an economic baseline was being developed utilizing the AG-GEM model. AG-GEM is the result of a merger between the AGSIM agriculture sector model developed by Robert Taylor at Auburn University and the COMGEM macroeconomic model developed by John Penson and Dean Hughes at Texas A&M University.

AGSIM provides national and regional estimates of production, prices, and income by commodity. Regional supply functions are estimated utilizing ERS/USDA cost of production data. This explains why it was necessary to obtain estimates of yield reduction and cost changes based on the ERS yields and costs for each chemical use reduction scenario. The regional crop sector of the model interacts with aggregate domestic and export demand functions to produce equilibrium crop prices, which, in turn, are reflected in the livestock sector of the model to give equilibrium livestock, poultry, and dairy prices. Income levels, consumer expenditures, and net aggregate export levels are then computed.

> “*The research results and/or expertise of more than 140 crop scientists were used in this study.*”

Throughout this process, the agriculture component of the AG-GEM model interacts with the macroeconomic component to take into consideration the effects of tax and government spending policy on inflation and interest rates, and in turn on supply and demand by commodity. This makes it possible to evaluate simultaneously the impacts of changes in government policy on farmers, on the agribusiness sector, on food price inflation, and on the consumer price index (CPI).

Once the baseline was developed, cost and yield information for each chemical use reduction scenario was sequentially integrated into the AG-GEM model to obtain economic impacts. In addition to the baseline, this economic impact analysis emphasized two options:

- No pesticides (NO H, I&F)
- No chemicals (NO CHEM)

To take into account the residual effects of chemicals on production, the full effect of yield reductions was achieved on the fourth year after a three-year period of carryover effectiveness from chemicals previously applied. In other words, in 1991, even though no chemicals were applied, there was assumed to be a 50 percent residual carryover effectiveness from chemicals applied in 1990 and previous years. In 1993, the carryover effectiveness fell to 30 percent. In 1993, it was only 10 percent. By 1994, no carryover effectiveness was assumed from previous years. Consequently, 1994 would be the first year in which the full impact of reduced chemical use could be measured in crops. In dairy and beef, however, the full impact of reduced chemical use in crops was not expected until years later due to their longer production cycles.

---

[2] To facilitate working arrangements, the agricultural economist was selected from the same land-grant university as the crop scientist.

Policy Assumptions

With each scenario, the farm program parameters were evaluated and adjusted to be consistent with the supply-demand conditions and the overall farm policy objectives.

Farm Policy

For farm programs, the following assumptions were made:

- The Conservation Reserve Program (CRP) was maintained at a level of 34 million acres.
- Acreage Reduction Program (ARP) requirements were made relative to stock/commodity use relationships.
- The Expanded Export Promotion Program (EEP) was discontinued.
- Minimum pipeline stocks relative to domestic consumption were established at a level that approximated those of the world food crisis in 1973 and 1974.

Macroeconomic Policy

The following assumptions were made regarding macroeconomic policy:

- The Federal Reserve would adopt a tighter monetary policy when the implicit GNP price deflator showed signs of exceeding a 4.5 percent annual inflation rate.
- An attempt was made to achieve the Gramm-Rudman-Hollings balanced budget target by 1993 through holding real government spending constant while moderately increasing personal income taxes.
- These monetary and fiscal policies were moderated whenever the economy's real growth fell below an annual rate of 1.5 percent.

Import Policy

Perhaps the most important assumption made in the study involved import policy. Four *alternative* assumptions were considered:

- **No increased chemical restrictions placed on imports.** This import policy option would allow increased imports based on contemporary safety standards, inspection procedures, and economic conditions. If restrictions on the use of chemicals substantially reduce domestic yields and increase commodity prices, unrestricted imports would likely have a very adverse impact on domestic agriculture. Equally important, unrestricted imports would be inconsistent with the objectives of chemical use reduction designed to deal with food safety, water quality, and global environmental concerns. If chemicals were used in other countries, unrestricted imports would not protect the safety of the U.S. food supply. In addition, unrestricted imports would, in effect, be exporting environmental problems associated with chemical use. In other words, it would not encourage environmentally sound policies in other countries.
- **Require extensive testing of imports for chemical residues and convert the cost of testing into a tariff.** Testing for residues is extremely costly. The chemicals used in production do not always show up in the tests. While it might be argued that products should be allowed to enter the United States if chemical residues are not detected, such a policy would discriminate against U.S. farmers who would be prohibited from using the chemicals because of concerns such as impacts on water quality. In addition, increased testing does not necessarily deal with global environmental concerns.
- **International chemical cross-compliance.** This concept implies that countries would be required to maintain the same chemical use restrictions as the United States in return for the right to import. International chemical cross-compliance could increase costs of production to foreign producers and, therefore, might not require more stringent restrictions on imports. Since land would be a more important input under conditions of reduced chemical use, those countries that could bring new land into production would have an advantage.

While international chemical cross-compliance is an appealing idea, it would be very difficult to enforce. Extensive testing for residues would still be required. In addition, to assure compliance, a system for on-site inspection could be required because chemical residues do not always remain on crops.

- **Maintain imports at current levels.** This option would, in effect, establish an import quota at the level that existed before the chemical use reduction policy was implemented. Under this option, import quotas would be imposed to prevent products from being imported if they were produced with the aid of chemicals banned in the United States. While such a policy is harsh and would run counter to GATT, this option was judged to be the only effective and politically feasible means of implementing an equitable environmental policy designed to substantially reduce agricultural chemical use. As a result, this option was selected as the basis for import policy in this study.

Procedural Summary

The study relied on the best scientific data available. These data were derived from leading plant and social scientists to determine, among other things, yield and cost impacts. Previously tested and extensively utilized economic models were used to evaluate the economic impacts on feed grain, wheat, and cotton producers; agribusiness management and employees; and consumers. This analysis took place within the current macroeconomic and farm program setting. Quotas were imposed on U.S. imports as a means of preventing products from entering the country if they were produced with the aid of chemicals banned in the United States.

CHAPTER TWO

INITIAL CROP SECTOR IMPACTS

This chapter summarizes the results of yield, crop rotation, and variable cost estimates for each chemical use reduction scenario as obtained from the lead crop scientists and the agricultural economists. In other words, this chapter summarizes the scientific data utilized in the AG-GEM model to determine the broader economic impacts of chemical use reduction. These estimates of these scientists included adjustments in crop rotation patterns, utilization of green manure, increased cultivation, and other production considerations.

Emphasis in this chapter is placed on the national results although the regional results for each crop are summarized in terms of the range of impacts determined to exist. The baseline for the analysis was the yields and costs as reported in the economic indicator series of the publication titled *Cost of Production, 1987*. For all crops except peanuts and rice national results were obtained by weighting the regional yield based on regional acreage generated by AG-GEM in 1994. U.S. rice and peanuts were derived by weighting initial results by current planted acreage. A detailed presentation of the national and regional crop yield and variable cost impacts is contained in the companion publication titled Impacts of Chemical Use Reduction on Crop Yields and Costs.

Overview of Results

In general, substantial reductions in yields were projected under the no pesticide and no chemicals options. Table 1 is designed to provide an overall summary of the national average yields, costs and the regional range of estimates. For the year in which these crops were grown, the smallest U.S. yield reductions from complete chemical elimination were in sorghum (37 percent) and soybeans (37 percent). The largest U.S. yield reductions were in peanuts (78 percent), rice (63 percent), and cotton (62 percent). If reduced production due to crop rotation and fallowing were considered, these yield reductions would be even larger.[3]

With the exception of wheat, the largest regional reductions in yields were in the humid and warm climates of the South. Insects, fungi, and weeds generally are more prolific with higher temperatures, more humidity, less severe winters and longer growing seasons. For crops grown in both regions, such as corn, yield reductions were 50 percent greater in the Southeast and Southwest (72 percent) than in the Corn Belt (48 percent). In wheat, yield reductions were more than twice as large in the Southern Plains (30 percent) as in the Central Plains (14 percent). For the Southern crops of rice, cotton, and peanuts, yield reductions always exceeded 50 percent and generally exceeded 60 percent on a regional basis. However, there were exceptions to the rule that Southern crops experience larger yield reductions. For example, Northwest wheat experienced the greatest reduction among the wheat regions (58 percent).

---

[3] Attempts made to uniformly annualize yields by considering changes in rotation patterns proved unsuccessful. While yields and costs can be easily annualized if the land is idled (fallowed or green manure), it is extremely difficult if a commercially harvested crop is substituted.

Table 1. National Percentage Yield Reduction, Range of Regional Percentage Reduced Yields, and Total Economic Cost/Unit for the No Chemicals Option.*

Crop, Region and Units	Percent Change in Yield	Cost Per Unit		
		ERS Cost/Unit	No Chemical Cost/Unit	Percent Increase
	(Percent)	-----------Dollars-----------		(Percent)
Peanuts (pounds)				
National	- 78	0.22	0.72	224
Southern Plains	- 72	0.25	0.73	191
Virginia and North Carolina	- 81	0.22	0.78	251
Rice (cwt)				
National	- 63	7.55	17.58	133
Arkansas	- 61	7.08	16.63	135
California	- 72	7.28	20.98	188
Delta	- 62	7.47	14.88	99
Cotton (pounds)				
National	- 62	0.63	1.38	118
Southeast	- 59	0.75	1.17	56
Southwest	- 53	0.70	1.44	107
Delta	- 68	0.57	1.37	142
Corn (bushels)				
National	- 53	2.05	3.30	61
Corn Belt	- 48	2.00	2.91	45
Southeast	- 72	2.69	6.85	155
Southwest	- 72	2.43	6.48	167
Wheat (bushels)				
National	- 38	3.64	5.45	50
Central Plains	- 14	2.86	3.34	17
Northwest	- 58	3.15	5.95	89
Northern Plains	- 41	3.53	5.67	61
Northeast	- 35	5.16	7.59	47
Southern Plains	- 30	5.72	7.58	32
Soybeans (bushels)				
National	- 37	4.95	7.20	45
North Central	- 33	4.74	6.50	37
Delta	- 51	6.17	11.71	90
Sorghum (bushels)				
National	- 37	1.97	3.30	68
Central Plains	- 37	1.83	2.96	62
Southern Plains	- 35	2.28	4.00	75
Barley (bushels)				
National	- 43	2.58	4.11	59
Northwest	- 57	2.58	4.78	85
Southern Plains	- 30	2.64	3.52	33
Northern Plains	- 41	2.46	3.94	60
Northeast	- 35	3.57	5.28	48

*** Table 1 only provides an indication of the range of estimates. Therefore, the results for all regions studied are not included in Table 1 but can be obtained from the companion publication titled *Impacts of Chemical Use Reduction on Crop Yields and Costs.***

Without exception, the percentage reduction in yield per acre nationally was greater than the percentage reduction in costs due to reduced chemical use. As a result, the unit cost of production rose as chemical use decreased. National average increases in unit total economic costs resulting from zero chemical use were substantial, ranging from 45 percent in soybeans to 225 percent in peanuts.

Unit cost increases likewise varied regionally for all crops. Consistent with generally higher yield reductions, the largest increases in unit cost tended to be in the South. These results mean that Southern states would likely be the most adversely affected by a chemical use reduction policy.

Corn

Nationally, under the no chemicals option, corn yields fell from an average of 122 bushels per acre to 58 bushels -- a 53 percent decline. Nitrogen fertilizer alone resulted in a 41 percent yield decline (Figure 1). Eliminating herbicides was estimated to result in a 30 percent reduction in yield per acre. The absence of pesticides reduced yields by 32 percent.

Regionally, under the no chemicals scenario, reductions in corn yields varied from 48 percent in the Corn Belt to 72 percent in the Southeast and the Southwest. The 72 percent reduction in yield for the Southwest resulted in a 167 percent increase in total economic costs -- from $2.43 per bushel to $6.48 (Table 1).

Soybeans

Under the no chemical option, U.S. soybean yields were estimated to fall 37 percent from 34 bushels per acre to 22 bushels (Figure 2). Almost all of this reduction (35 percent) was due to the elimination of herbicides. The absence of insecticides and fungicides resulted in only a 3 percent reduction in yields. Since soybeans are a legume, the elimination of nitrogen fertilizer had no effect on yields. Thus the absence of pesticides reduced yields 37 percent.[4]

Nationally, total economic costs per bushel for soybeans were estimated to rise by 45 percent under the no chemicals scenario. Costs per bushel rose by 37 percent in the North Central region and by 90 percent in the Delta (Table 1).

Wheat

The no chemicals scenario reduced U.S. wheat yields by 38 percent (Figure 3). The largest yield reduction was due to the elimination of herbicides (23 percent) and no nitrogen fertilizer (16 percent). While the elimination of insecticides and fungicides was only projected to result in a 4 percent yield reduction, the scientists mentioned the potential for substantial yearly and local variation in yields due to pests such as grasshoppers and to uncertainties regarding the Russian wheat aphid. Therefore, the no pesticide option reduced yields by 24 percent.

> “*The largest increases in unit cost tended to be in the South, which means that Southern states would likely be the most adversely affected by a chemical use reduction policy.*”

Regional variation in the reduction in wheat yields was the largest of any crop analyzed. This result was partially due to the inability to annualize yields when significant adjustments had been made by the crop scientists' crop rotation patterns. Under the no chemical option, wheat yield reductions were more than four times as large in the Northwest where white wheat predominates than in the Central Plains (Table 1). Consistent with its 14 percent yield reduction, total economic costs per bushel in the Central Plains increased by only 17 percent. In the Northwest, unit costs increased by 89 percent under the no chemical option. The total economic cost per bushel increased by 61 percent in the Northern Plains region under the no chemical option with a 41 percent reduction in yield.

Cotton

U.S. cotton yields fell 62 percent under the no chemical option and 39 percent with no pesticides (Figure 4). The individual chemical group reductions were no nitrogen fertilizer (37 percent), no insecticides and fungicides (26 percent), and no herbicides (17 percent).

Regional variation in yield reduction was not as

---

[4] It will be noticed that the impacts of withdrawing individual chemicals are not additive. That is, the effect of withdrawing a combination of chemicals is not simply a process of adding up the yield effects of each individual chemical that compromises the combination. The difference results from the interaction of different pesticides and nitrogen fertilizer on yields.

Figure 1

U.S. Percentage Reduction in Corn Yield/Acre by Chemical Use Reduction Scenario

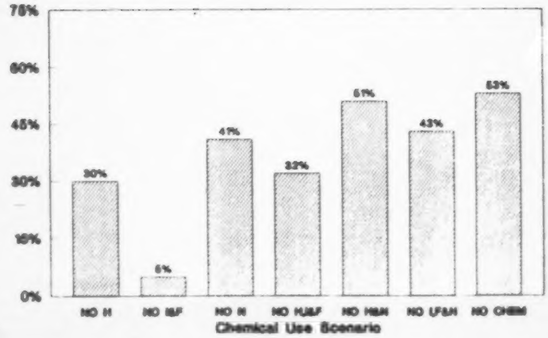


Figure 2

U.S. Percentage Reduction in Soybean Yield/Acre by Chemical Use Reduction Scenario

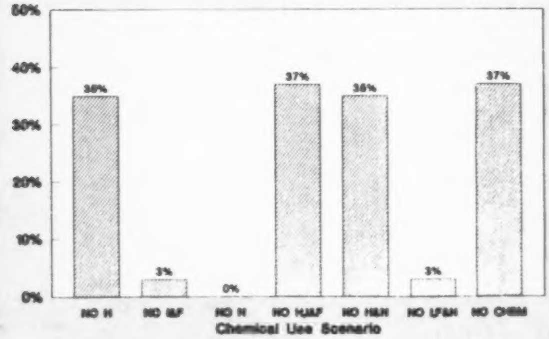


Figure 3

U.S. Percentage Reduction in Wheat Yield/Acre by Chemical Use Reduction Scenario

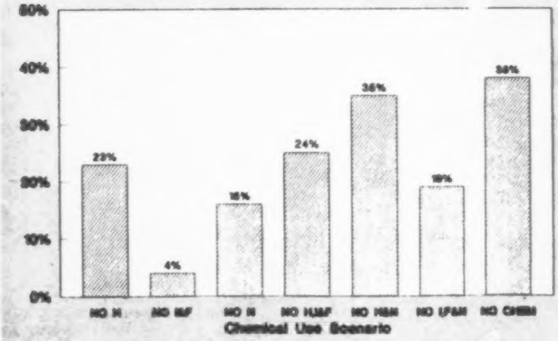


Figure 4

U.S. Percentage Reduction in Cotton Yield/Acre by Chemical Use Reduction Scenario

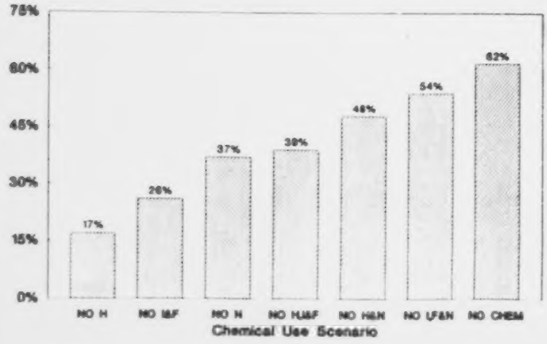


Figure 5

U.S. Percentage Reduction in Peanut Yield/Acre by Chemical Use Reduction Scenario

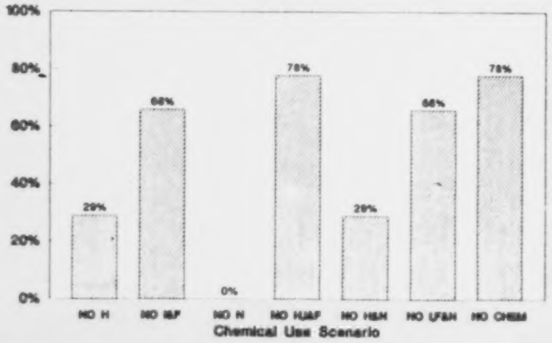
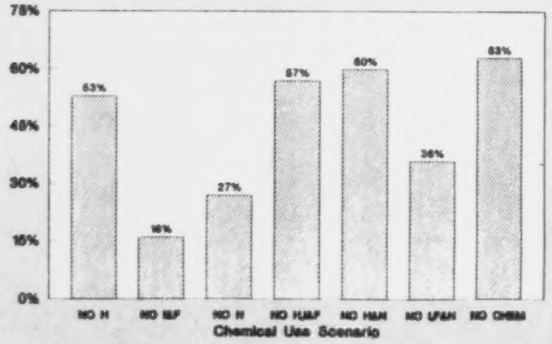


Figure 6

U.S. Percentage Reduction in Rice Yield/Acre by Chemical Use Reduction Scenario



pronounced for cotton as for the other crops studied. They ranged from 53 percent in the Southwest to 68 percent in the Delta (Table 1). However, total economic costs per pound fluctuated regionally with a 142 percent increase in the Delta compared to a 56 percent increase in the Southeast.

Peanuts

Peanut yields were devastated by reduced chemical use. No chemical use and no pesticides resulted in an estimated 78 percent U.S. yield decline (Figure 5). Most of this drop was due to the elimination of fungicides, with a 66 percent drop in yield for the no insecticide-no fungicide group. However, the elimination of herbicides accounted for a 29 percent reduction in peanut yields. Since peanuts are a legume, the elimination of nitrogen does not affect yields. The regional range of yield reduction was only 9 percentage points.

Nationally, total economic costs per pound were estimated to increase by 225 percent from $0.22 per pound to $0.72 under the no chemical scenario. The range in cost increases was larger than the yield difference. Costs per pound increased by 191 percent in the Southern Plains but by 251 percent in the Virginia and North Carolina region.

Rice

Nationally, rice yields fell 63 percent from 5,467 pounds per acre to 2,023 pounds under the no chemical option (Figure 6). The largest reduction was due to the elimination of herbicides (53 percent), but no nitrogen fertilizer (27 percent) and no insecticides-no fungicides (16 percent) also accounted for substantial yield reductions. The no pesticide option reduced rice yields by 57 percent. Yield reductions ranged from 61 percent in the Arkansas (non-Delta) region to 72 percent in California.

Like peanuts, rice experienced large cost increases. Under the no chemical option, U.S. total economic costs rose by 133 percent. Delta rice production costs per cwt doubled while California costs tripled.

Sorghum

Without chemicals, national sorghum yields fell by 37 percent (Figure 7). The reduction was due to the elimination of nitrogen fertilizer (18 percent) and insecticides and fungicides (20 percent). Weeds were controlled by a crop rotation pattern which included sorghum and alfalfa. No pesticides resulted in a 20 percent reduction in sorghum yields.

Regionally, sorghum yields dropped uniformly by 37 percent on the Central Plains and by 35 percent on the Southern Plains. However, total economic costs per bushel increased by 62 percent on the Central Plains and 75 percent on the Southern Plains.

Barley

Without chemicals, national barley yields fell by 43 percent (Figure 8). The largest reduction was due to the absence of herbicides (28 percent) and nitrogen

Figure 7

U.S. Percentage Reduction in Sorghum Yield/Acre by Chemical Use Reduction Scenario

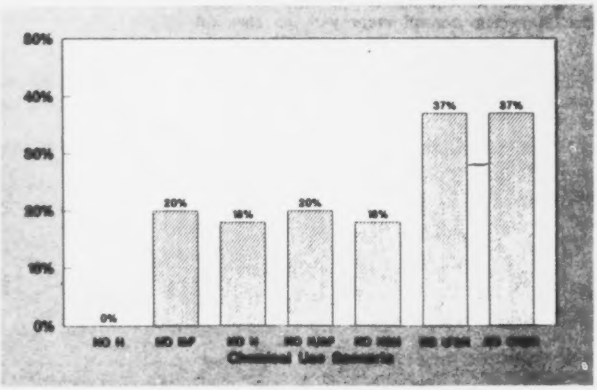
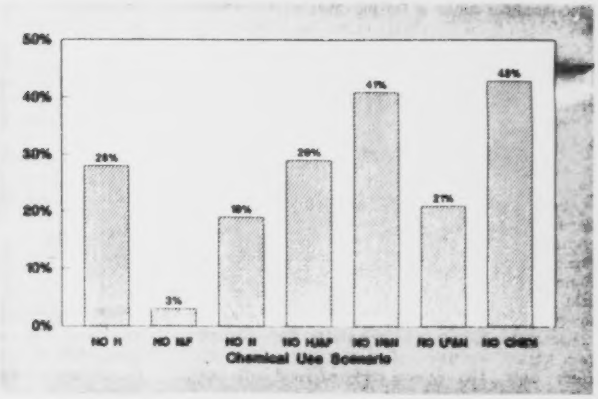


Figure 8

U.S. Percentage Reduction in Barley Yield/Acre by Chemical Use Reduction Scenario



(19 percent). No pesticides caused barley yields to fall by 29 percent. In the Northwest, nitrogen had a larger impact (43 percent) and, therefore, a larger total yield reduction was experienced in the Northwest (57 percent) than in the other regions.

Total economic costs per bushel for barley increased by 85 percent in the Northwest under the no chemical scenario. The smallest cost increase was in the Southern Plains region with a 33 percent rise.

Conclusions

The national reduction in yields averaged more than 35 percent for all crops with no chemical application. In several cases, yield reductions were more than 60 percent -- particularly in the Southern regions. Yields fell more in percentage terms than costs declined. Therefore, without exception, total unit costs of production rose. Looked at in a positive sense, these results provide an indication of the contribution chemical technology has made to modern commercial agriculture in terms of increased yields and reduced production costs.

CHAPTER THREE

PRODUCTION, PRICE, AND UTILIZATION IMPACTS

This chapter presents the impacts of reduced yields, changes in production practices, and increase in variable costs for the agricultural crop and livestock sector. The initial baseline cropping and regional production patterns generated by the AG-GEM general equilibrium agricultural sector and macroeconomic model were consistent with those currently existing. The results from the chemical reduction scenarios reflect changes in cropping and regional production patterns relative to the baseline. Rice and peanuts were analyzed independent of the AG-GEM model.

Emphasis in this discussion is placed on the implications of reduced chemical use for the aggregate levels of production, impacts on prices, and utilization of commodities in terms of domestic and export market segments. Price impacts are evaluated initially for the crop sector and then for the livestock, dairy, and poultry sectors. Because of the impacts of livestock, dairy and poultry production cycles, the results are presented for both crops and livestock covering the years 1995-1998. Even then, for the dairy and beef sector, the economic impacts of chemical use reduction in terms of increases in milk or beef prices are not yet fully realized in 1998. Supply, price, and utilization tables for each of the major scenarios evaluated are included in Appendix B for the years 1990-94 as an indication of annual price movements during the early period of adjustment.

Chemical Use Reduction Scenarios

For simplicity, emphasis in this and the next chapter is placed on only three of the policy and chemical use reduction scenarios:

- **A current practice baseline scenario** represents a continuation of the agricultural, trade, and environmental policies contained in the 1985 farm bill as summarized in Chapter 1. Some of the key farm program assumptions for individual crops are included in the Appendix B tables. The baseline also assumes a continuation of the macroeconomic policies that emphasize continued modest economic growth with monetary restraint to control inflation.

- **A no pesticides scenario** removes all herbicides, insecticides, and fungicides from the market with the exception of seed treatments and harvest aid chemicals in cotton. As indicated in Chapter 1, CRP land is maintained at 34 million acres. However, annual ACR acreage is drawn back into production. Likewise, the export enhancement programs are discontinued inasmuch as less commodities are available for export. Import quotas are established at 1989 levels as a policy designed to protect consumers, the global environment, and farmers.

- **A no chemicals scenario** removes all chemicals including pesticides (except as noted) and inorganic nitrogen fertilizer. This scenario makes the same assumptions regarding farm, environment, and trade policy as indicated above for the no pesticides scenario.

Throughout the analysis for the alternative chemical use reduction scenarios, imports of agricultural commodities were assumed to be frozen at the baseline levels. It was also assumed that producers would respond to economic signals perfectly and instantaneously while continuing to devote their fixed resources (land, etc.) to agricultural production. This assumption is not trivial because of the tremendous changes that can occur in the management requirements and risk associated with farming.

Crop Sector Impacts

The first year in which the full effects of reduced chemical use policies on the crop sector can be evaluated is 1994.[5] Therefore, the following crop sector results compare the baseline outcomes with the no pesticide and no chemical outcomes in 1995-98. The results for subsequent years are not materially different in the case of crops. While only the production, yield, price, and utilization impacts for the period 1995-98 are discussed here, details on developments between 1990 and 1994 can be obtained from Appendix B. It needs to be emphasized that the results presented in this chapter take into consideration regional adjustments in acreage as well as the economic incentives for farming intensity implied by the increased price. Changes in crop production patterns are summarized in this chapter but are discussed in greater detail in Chapter 4 and presented in Table 2.

Corn

Corn yield per harvested acre in 1995-98 would decline by 38 percent from an average 122 bushels per acre using current practices to 76 bushels with no

Figure 9. U.S. Corn Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

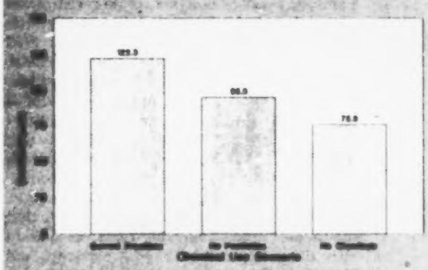


Figure 10. U.S. Corn Production by Chemical Use Reduction Scenario, 1995-98.

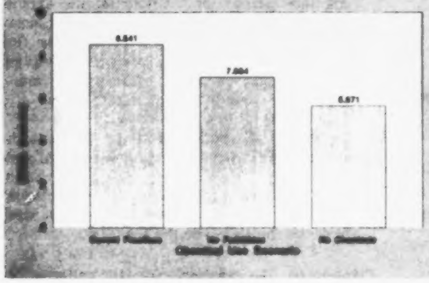


Figure 11. U.S. Corn Prices by Chemical Use Reduction Scenario, 1995-98.

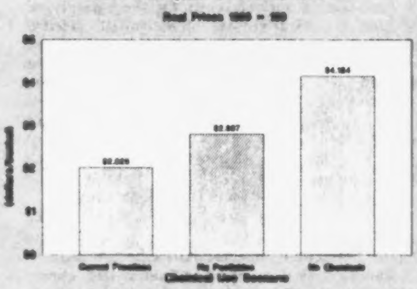
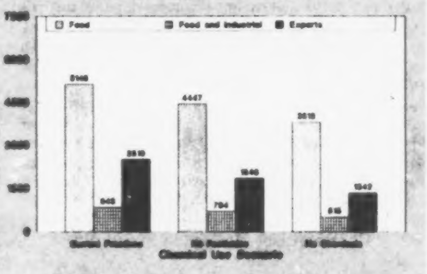


Figure 12. U.S. Corn Utilization by Chemical Use Reduction Scenario, 1995-98.



---

[5] As indicated in Chapter 1, reduction in yields was phased in over four years due to the residual effects of chemicals used in the past.

chemical use (Figure 9). Based on current practices, corn production in 1995-98 was projected to average more than 8.5 billion bushels annually. Production under the no pesticide option would fall 18 percent to 7 billion bushels while production under the no chemicals scenario would fall 34 percent to less than 5.7 billion bushels (Figure 10). With no pesticides, this production decrease would result in a 38 percent real price increase from $2.03 per bushel using current practices to $2.81 per bushel (Figure 11). With no chemicals the real price of corn would double to $4.16 per bushel. Corn acreage would increase overall in traditional growing regions such as the Corn Belt and the Northern Plains.

Higher prices would curb the utilization of corn, particularly for export. Net sales volume would fall 26 percent from 2.5 billion bushels to 1.8 billion with no pesticides and would decline by 47 percent with no chemicals (Figure 12). Under the no chemical scenario, food and other uses of corn would fall by 39 percent while feed use would drop by 26 percent. The drop in food use could be largely attributed to the reduced competitiveness of HFCS corn sweeteners.

Soybeans

Soybean yields in 1995-98 would decline from 35 bushels per acre to 23 bushels with no pesticides and/or no chemicals (Figure 13). Soybean production was projected to total more than 2.1 billion bushels based on current practices. With no pesticides, production was projected to fall 26 percent to about 1.6 billion bushels (Figure 14). Soybean production would increase slightly under the no chemical scenario compared to the no pesticide scenario but would still decline about 26 percent relative to the current practices baseline.

As indicated in Figure 15, real soybean prices would double in response to the no pesticides ($11.36 per bushel) option. Under the no chemical scenario,

Figure 13. U.S. Soybean Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

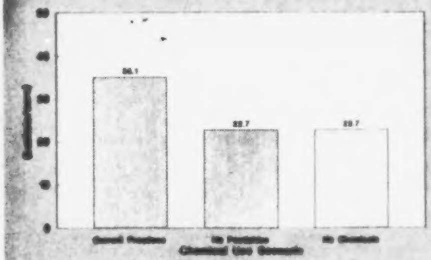


Figure 15. U.S. Soybean Prices by Chemical Use Reduction Scenario, 1995-98.

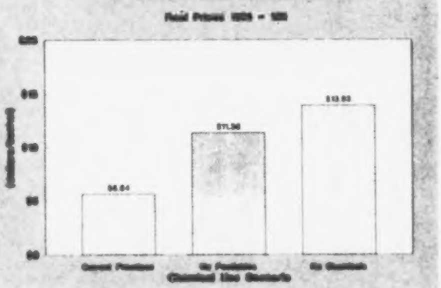


Figure 14. U.S. Soybean Production by Chemical Use Reduction Scenario, 1995-98.

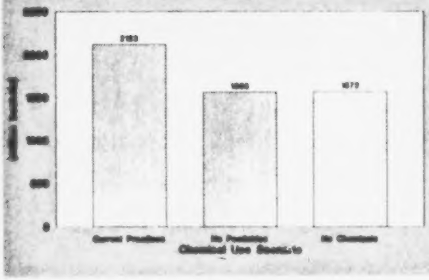
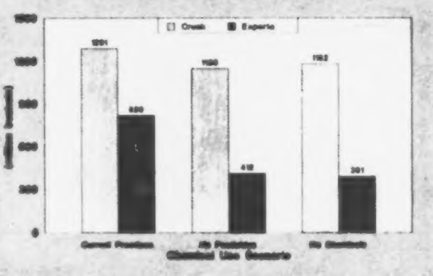


Figure 16. U.S. Soybean Utilization by Chemical Use Reduction Scenario, 1995-98.



the price would increase by nearly 150 percent to average $13.93 over the 1995-98 period. Soybean acreage would increase in most traditional growing regions, particularly in the absence of inorganic nitrogen fertilizer.

Higher soybean prices would cause exports to decline by about 50 percent under both reduced chemical scenarios (Figure 16). Crush uses would be maintained at more than 1.1 billion bushels to fill livestock and poultry demands.

Wheat

Wheat yields would decline 25 percent from 34 bushels per acre under current practices to 28 bushels with no pesticides. With no chemicals, wheat production would decline 34 percent to 23 bushels (Figure 17). Production in 1995-98 was projected to average nearly 2.6 billion bushels using current practices. However, production would fall 9 percent to 2.4 billion bushels with no pesticide use and decline by 27 percent to about 1.9 billion bushels with no chemical use (Figure 18). In response to lower production, the price of wheat would increase 6 percent from $3.04 per bushel under the baseline to $3.21 with no pesticides (Figure 19). However, with no chemicals the wheat price would increase 19 percent to $3.62 per bushel. Except in the Corn Belt, wheat acreage would increase in most major growing regions, particularly under the no pesticide option.

Wheat utilization reflects a highly inelastic domestic consumer response to higher wheat prices. Therefore, domestic use would fall very little despite the large price increase under the no chemicals option (Figure 20). Under the no chemicals option, wheat exports would tumble by 47 percent from 1.49 billion bushels to 837 million bushels. A large share of the wheat market would be lost to competitors such as Canada, Australia, Argentina, and the European Economic Community.

Figure 17. U.S. Wheat Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

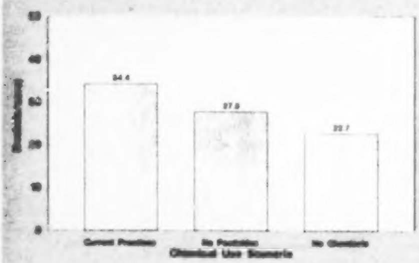


Figure 19. U.S. Wheat Prices by Chemical Use Reduction Scenario, 1995-98.

Real Prices 1989 = 100

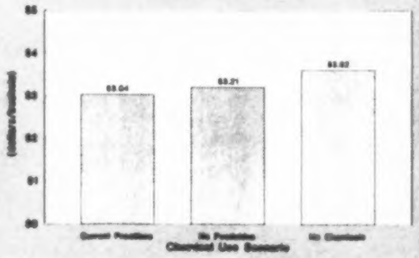


Figure 18. U.S. Wheat Production by Chemical Use Reduction Scenario, 1995-98.

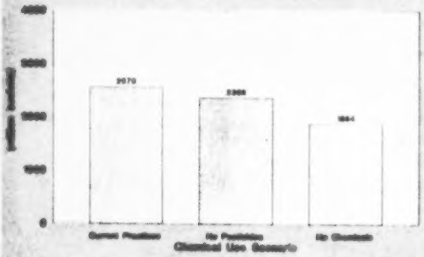
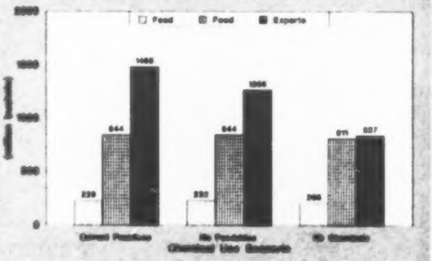


Figure 20. U.S. Wheat Utilization by Chemical Use Reduction Scenario, 1995-98.



Cotton

The cotton yield would fall 62 percent from 661 pounds per acre to 253 pounds under the no chemical option (Figure 21). No chemicals would reduce production to only 7.2 million bales -- a 56 percent reduction from the current practices baseline (Figure 22). A reduced production of 30 percent, from 16.4 million bales to 11.5 million, would be precipitated by the withdrawal of pesticides.

Under no pesticides, the real price of cotton would rise more than 34 percent from $0.56 to $0.75 per pound (Figure 23). However, the no chemicals scenario would generate a $1.12 per pound cotton price -- double the price using current conventional farming practices. Cotton acreage would increase materially only in the Southern Plains. Since the cotton price increases encourage mills to utilize synthetics as opposed to natural fibers, the result would be a 15 percent reduction in domestic fiber use under the no pesticide option and a nearly 35 percent decline with no chemicals (Figure 24). The export market would be devastated under the no chemical scenario, declining 76 percent from 7.9 million bales to 1.9 million bales. A 46 percent decline in exports would occur with no pesticides.

Peanuts

The impacts of chemical use reduction on peanuts were analyzed independent of the AG-GEM model. Because of the relative lack of economic research on peanuts, the analysis was not extended beyond 1994. Peanut yields in 1994 would decline from 2,714 pounds per harvested acre utilizing current practices to 683 pounds under the no pesticides and no chemicals scenarios (Figure 25). In 1994, total peanut production was projected to reach nearly 4.6 billion pounds using current practices but would fall to 3.8 billion pounds with no pesticides and chemicals (Figure 26). Assuming that U.S. producers would be protected from

Figure 21. U.S. Cotton Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1990-94.

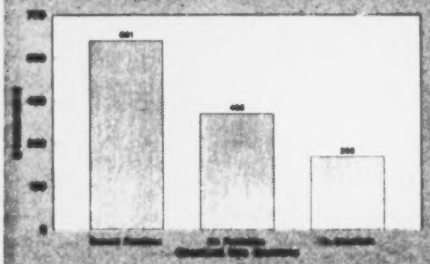


Figure 22. U.S. Cotton [illegible] Use Reduction Scenario, [illegible]

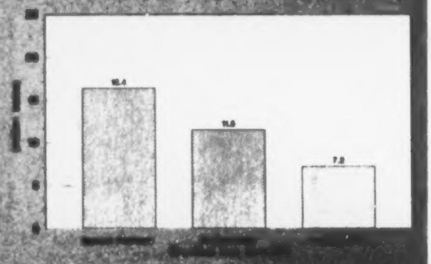


Figure 23. U.S. Cotton Prices by Chemical Use Reduction Scenario, 1990-94.

[illegible]

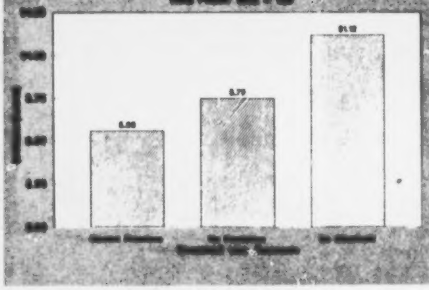
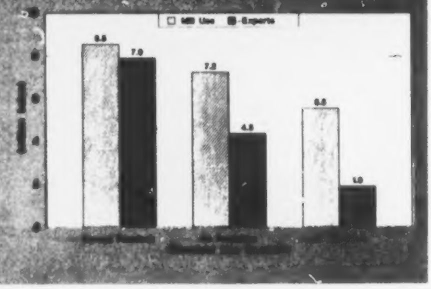


Figure 24. U.S. Cotton [illegible] Use Reduction Scenario, [illegible]



imports, peanut acreage would expand sufficiently to satisfy this domestic demand. In response to lower production, the price of peanuts would increase from $0.313 per pound to $0.773 per pound (Figure 27).

The major change in the utilization of peanuts would be the complete elimination of the export market (Figure 28). Peanut exports are dependent on the current two-price peanut program. With the higher cost, the feasibility of maintaining the export market with significantly higher costs would be in serious doubt. The other major change in peanut utilization involved a 256 percent increase in the use of peanuts for seed due to increased acreage under the no pesticides and no chemicals option.

Rice

In 1995-98, the rice yield would decline 64 percent from 59.5 cwt per acre under current practices to 21.5 cwt with no chemicals (Figure 29). Under the no pesticide scenario, yields would decline 58 percent to 25 cwt per acre. The no chemical scenario would result in about one-half the production that would exist under current chemical use practices (Figure 30). The result would be a real rice price that would increase by 83 percent to $9.76 per cwt with no chemicals, compared with $9.71 under no pesticides and $5.32 with current practices (Figure 31). The higher price would virtually cut off the export market causing it to decline by 77 percent from 83 million cwt to 19.4 million cwt with no chemicals (Figure 32). Domestic consumption would decline 20 percent from 94 million cwt using current practices to 75 million cwt under the no chemical scenario.

Sorghum

The sorghum yield would decline 8 percent from 63 bushels per acre using current practices to 58 bushels under the no chemicals scenario (Figure 33). Sorghum production would attract acreage under the

Figure 26. U.S. Peanut Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1994.

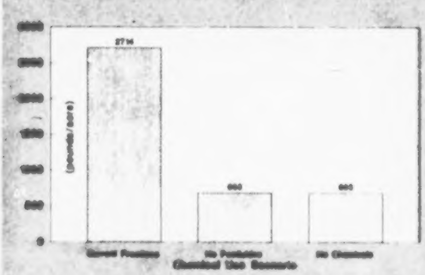


Figure 27. U.S. Peanut Prices by Chemical Use Reduction Scenario, 1994.

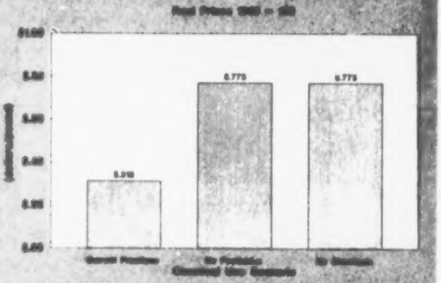


Figure 28. U.S. Peanut Production by Chemical Use Reduction Scenario, 1994.

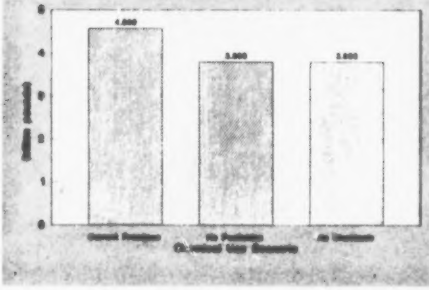
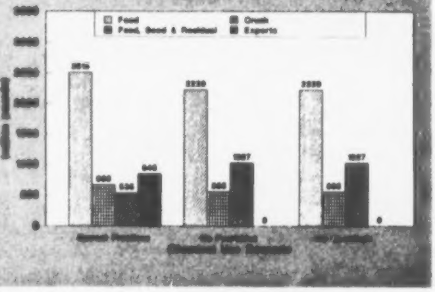


Figure 29. U.S. Peanut Utilization by Chemical Use Reduction Scenario, 1994.



no pesticide option. As a result, production would rise from 746 million bushels to 779 million bushels but would fall to 701 million bushels with no chemicals (Figure 34). Despite increased production, the real price of sorghum would rise from $1.97 per bushel to $2.25 with no pesticides due to the increased price of corn (Figure 35). Under the no chemical scenario, sorghum production would fall 6 percent from 746 million bushels under current practices to 701 million bushels. The real sorghum price would increase by 54 percent under the no chemicals option as a result of the combination of reduced production and the interaction of the price of sorghum with the price of corn. While feed use of sorghum would decline by 27 percent with no chemicals, exports actually would increase by 39 percent (Figure 36) because sorghum price relative to corn would fall to 73 percent. Arbitrage in the feed grain markets would likely result in sorghum price increases and a slight lowering of corn prices. As the arbitrage occurs it is unlikely that sorghum exports would increase over the long run.

Barley

U.S. barley yields would decline 36 percent from 54 bushels per acre to 34 bushels under the no chemical option (Figure 37). Under no pesticides, the yields would decline 26 percent to 40 bushels. Barley production would decline by nearly one-third with no chemicals (Figure 38). This decline in production would result in a 75 percent price increase. With an inelastic malting barley demand, the higher prices would reduce food use only 9 percent (Figure 39). Feed use would fall 36 percent while exports would decline 54 percent under no chemicals (Figure 40).

Livestock, Dairy and Poultry Sector Impacts

The major impact of chemical use reduction on the livestock, dairy, and poultry sector would be through the price of feed. Increased feed prices would sequentially mean higher costs of production; reduced

Figure 29. U.S. Rice Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

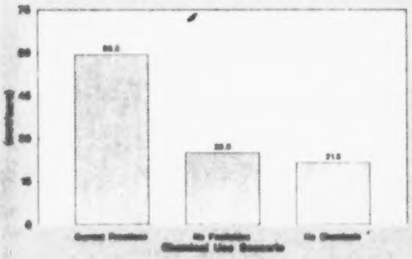


Figure 30. U.S. Rice Production by Chemical Use Reduction Scenario, 1995-98.

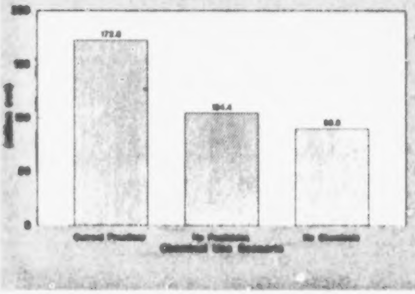


Figure 31. U.S. Rice Prices by Chemical Use Reduction Scenario, 1995-98.

Real Prices 1990 = 100

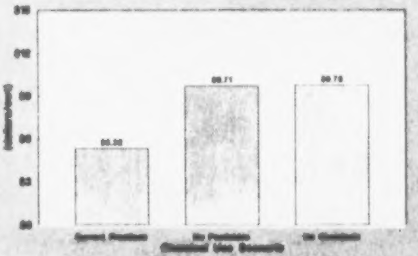
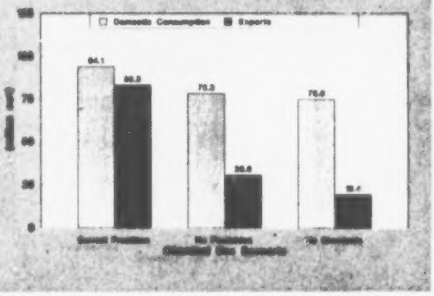


Figure 32. U.S. Rice Utilization by Chemical Use Reduction Scenario, 1995-98.



profits; reduced production; and eventually, increased livestock, dairy, and poultry prices.

Because of the shorter production cycle, poultry responds much more rapidly to higher feed costs than pork. Milk production responds more slowly than pork. Beef production responds more slowly than dairy. Sharply higher feed prices would result in increased utilization of forage legumes as opposed to grain feeding in beef production. Thus, forage would become a more important input, although it is anticipated that a large percentage of the beef would still be grain fed, but for a shorter time period.

As in the case of grains, the results are presented for the 1995-98 period and prices are in real 1989 dollar terms. However, it should be recognized that in the case of beef, where the production-price cycle extends over 8-10 years, the economic effects of reduced chemical use may extend considerably beyond 1998. As for the crop sector, details on livestock sector impacts through 1994 are contained in Appendix C.

Poultry

The poultry sector would respond rapidly to the increased feed costs that would be fully realized as early as 1994. While broilers, eggs, and turkeys are all incorporated in the model, the emphasis here is placed on broilers. The increase in the real price of corn, from $2.25 in 1990 to $5.96 in 1994, would begin to curb consumption and production beginning in 1993. By 1994, the price of broilers would rise 31 percent under the no chemicals option relative to the current practices baseline, and consumption would stagnate at 67 pounds. Broiler consumption would not decline as much as might otherwise be anticipated in response to the higher price because broad-based pressure on consumers' food budgets would shift preferences in the direction of the lowest priced meats. For the period 1995-98, broiler production would fall 4

Figure 33. U.S. Sorghum Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

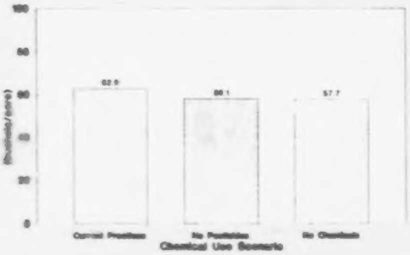


Figure 35. U.S. Sorghum Prices by Chemical Use Reduction Scenario, 1995-98.

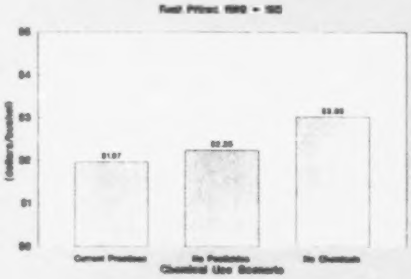


Figure 34. U.S. Sorghum Production by Chemical Use Reduction Scenario, 1995-98.

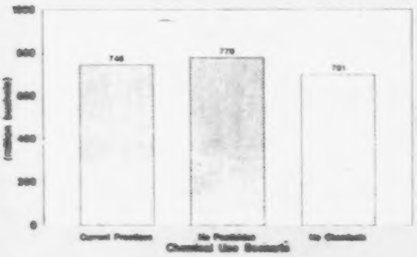
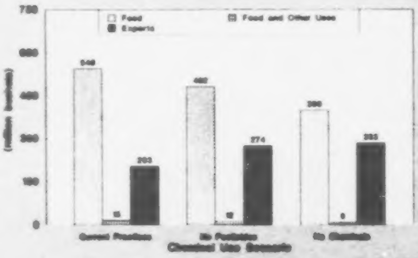


Figure 36. U.S. Sorghum Utilization by Chemical Use Reduction Scenario, 1995-98.



percent under the no chemicals scenario relative to the baseline (Figure 41). During this period, the real price of corn would average $4.16 per bushel, more than double the baseline price of $2.03. The real price of soybeans would average $13.93 per bushel compared with the $5.64 baseline. In response, under the no chemical scenario, the price of broilers would rise 33 percent in real 1989 dollars (Figure 42). No pesticides would yield a 20 percent broiler price increase. With this higher price, broiler consumption would stagnate at about 75 pounds per capita (Figure 43).

Pork

Hog producers would respond to higher feed prices less rapidly than broiler producers because of the longer production cycle. As a result, the production adjustment would begin to occur in 1994 with a 14 percent drop in processed pork production. Over the 1995-98 period, processed pork production would decline an average 27 percent under the no chemicals option and 13 percent with no pesticides (Figure 44). In response to the 27 percent decline in production, the real farm price for slaughter hogs would rise an average of 10 percent (Figure 45). The higher pork price would precipitate a 26 percent decline in pork consumption from 65 pounds per capita using current practices to 48 pounds under the no chemical option. With no pesticides, there would be a 14 percent decline in pork consumption per capita (Figure 46).

Beef

Higher feed prices, the option of grazing, interaction with dairy as a source of beef, the potential for substitution of other meats, and the cattle production-price cycle would make beef reactions to reduced chemical use considerably more complex than either hogs or poultry. This makes year-to-year prediction of beef price changes under the alternative chemical use reduction scenarios difficult.

Figure 37. U.S. Barley Yield Per Harvested Acre by Chemical Use Reduction Scenario, 1995-98.

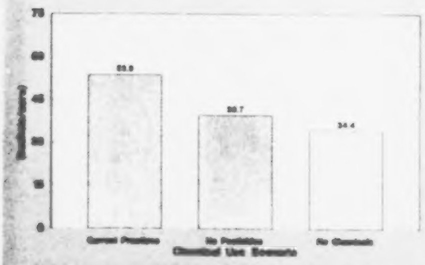


Figure 38. U.S. Barley Production by Chemical Use Reduction Scenario, 1995-98.

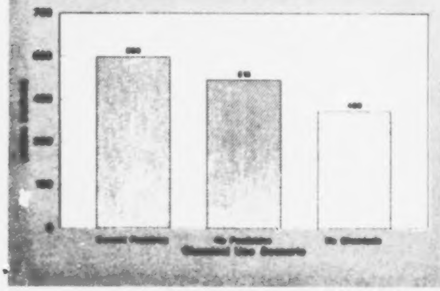


Figure 39. U.S. Barley Prices by Chemical Use Reduction Scenario, 1995-98.

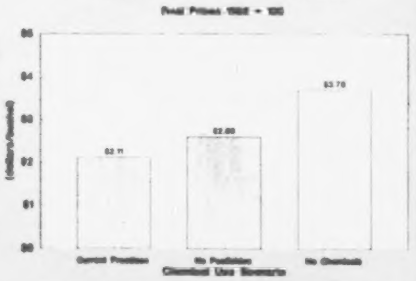


Figure 40. U.S. Barley Utilization by Chemical Use Reduction Scenario, 1995-98.

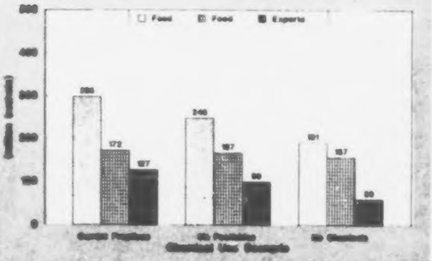


Figure 41. U.S. Broiler Production by Chemical Use Reduction Scenario, 1995-96 Average.

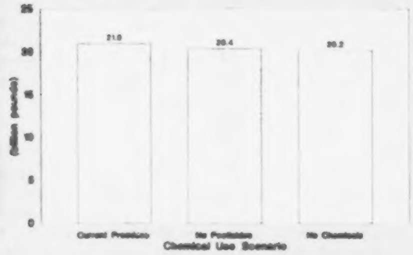


Figure 42. U.S. Broiler Price - 12 City Average - by Chemical Use Reduction Scenario, 1995-96 Average.

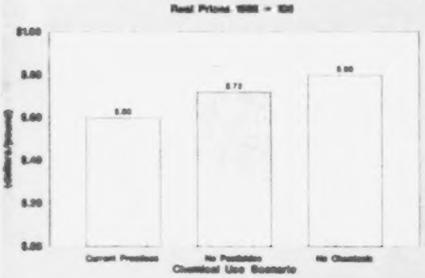


Figure 43. Broiler Consumption Per Capita by Chemical Use Reduction Scenario, 1995-96 Average.

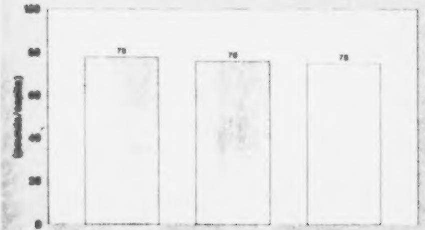


Figure 44. U.S. Processed Pork Production by Chemical Use Reduction Scenario, 1995-96 Average.

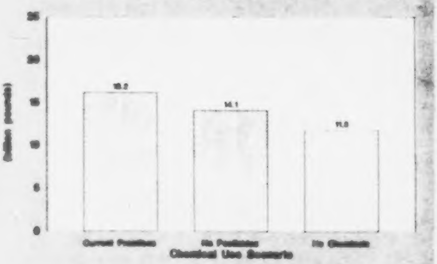


Figure 45. U.S. Farm Prices for Hogs by Chemical Use Reduction Scenario, 1995-96 Average.

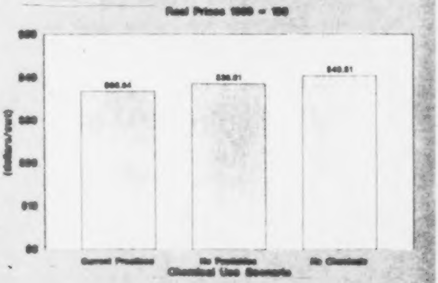
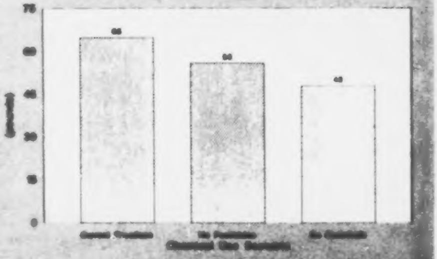


Figure 46. U.S. Pork Consumption Per Capita by Chemical Use Reduction Scenario, 1995-96.



The higher feed prices would result in an initial liquidation of the cow herd. Cow slaughter liquidation as early as 1991 is indicated (Figure 47). By 1994, an additional 1.52 million head of cows would be slaughtered. Steer and heifer slaughter would decline in 1994 as grass feeding would increase in response to high feed costs. For the period 1995-98, cow slaughter would be up an average of 450,000 cows (6 percent) relative to the baseline (Figure 48). On the other hand, with no chemicals, steer and heifer slaughter would decline by 14 percent, an average of 3.8 million head (Figure 48). In reaction, the price of steers and heifers would increase by 3 percent while cow prices would rise by 10 percent (Figure 49).

Higher beef prices would accelerate the decline in beef consumption. Therefore, per capita consumption of beef would fall 9 percent to 68 pounds under the no chemical option relative to the baseline of 75 pounds (Figure 50). This relatively small decline assumes that consumers would respond only to the price of beef and that beef fed for a longer time period on grass would be considered acceptable across a broad range of consumers.

Milk

Adjustment in the dairy industry occurs either in terms of the number of milk cows or output per cow. When feed prices rise sharply, the initial adjustment occurs by cutting back on concentrate feeding. As a result, output per cow falls. This, for example, happened in the drought of 1988-89. Subsequently, if the cost-price squeeze continues, there will be increased culling of cows. The dairy sector analysis did not consider the impacts of the potential introduction of BST during the 1990s.

This sequence of events, played out with the chemical use reduction scenarios analyzed, was precisely as expected. Milk output per cow normally has increased at a fairly consistent rate of 1.7 percent

Figure 47. U.S. Beef Slaughter by Chemical Use Reduction Scenario, [illegible]

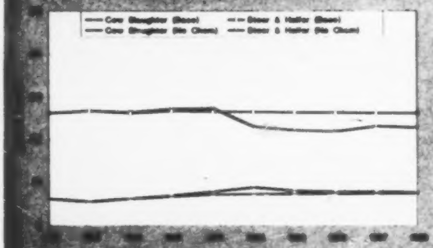


Figure 49. U.S. Price of Beef by Chemical Use Reduction Scenario, 1995-98 Average.

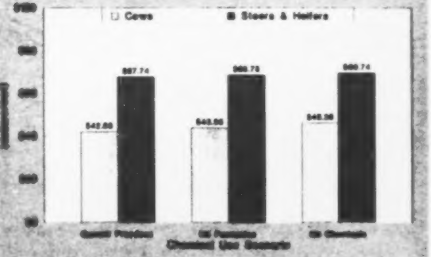


Figure 48. U.S. Beef Slaughter by Chemical Use Reduction Scenario, 1995-98 Average.

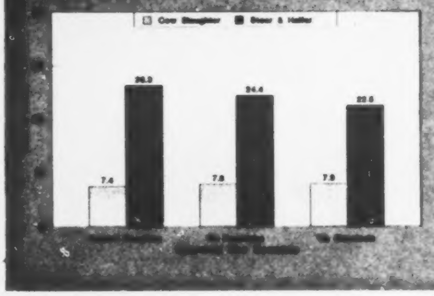
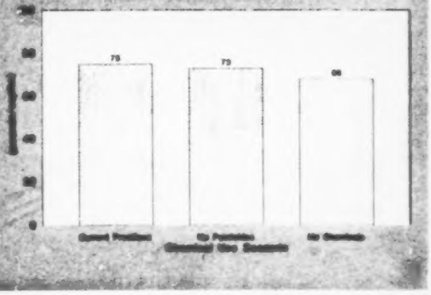


Figure 50. U.S. Beef Consumption Per Capita by Chemical Use Reduction Scenario, 1995-98 Average.



annually. In 1992, the rate of increase would slow under the no pesticide and no chemicals options as the gap would widen between the baseline and the two reduced chemical use options (Figure 51). Cow numbers would begin to decline in 1995 (Figure 52). As a result, milk production averages would be 3.0 billion pounds (2 percent) lower under the no chemical option in 1995-98 (Figure 53). In response to lower production, the real milk price would rise by 2 percent to $11.61 per cwt compared to $11.34 under the baseline (Figure 54). Therefore, milk consumption per capita would decline 2 percent from 573 pounds under the baseline to 562 pounds with no chemicals (Figure 55).

Implications

Chemical use reduction policies have a pervasive impact on crop prices, an impact that works its way through all livestock, dairy, and poultry enterprises. The results of this study clearly demonstrate the interrelation of the crop and livestock sector.

Modern agriculture has benefitted from the productivity of the crop sector and the advances made possible through technological change, including the use of chemicals. Because of biological and economic response lags, withdrawal of these chemicals would have productivity and price impacts that would extend many years into the future. The beef and dairy sectors are especially slow to adjust to changes or shocks in the economy. Thus, adjustments in the livestock sector would continue beyond 1998, the end of simulation in this study. After full biological and economic adjustment, the livestock price effects - particularly beef and dairy - would be larger than the estimated effects for the 1995-98 period. Therefore, short-run policy decisions could create long-run impacts. It is important for policymakers to consider carefully these long-run impacts before making major policy decisions.

Figure 51. U.S. Milk Output Per Cow by Chemical Use Reduction Scenario, 1991-98.

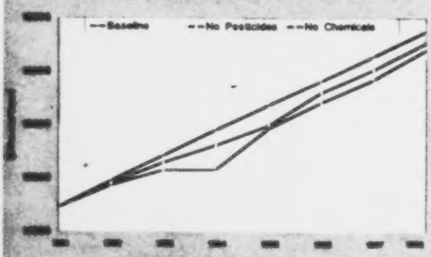


Figure 53. U.S. Milk Production by Chemical Use Reduction Scenario, 1995-98 Average.

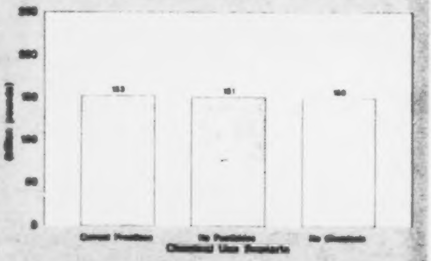


Figure 52. U.S. Beginning Inventory of Milk Cows, 1991-98.

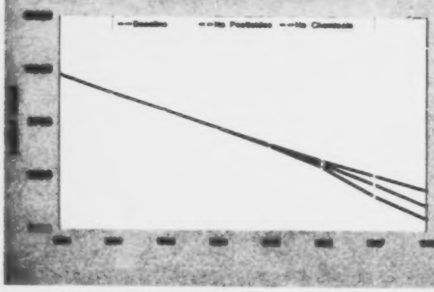


Figure 54. U.S. Milk Price by Chemical Use Reduction Scenario, 1995-98 Average.

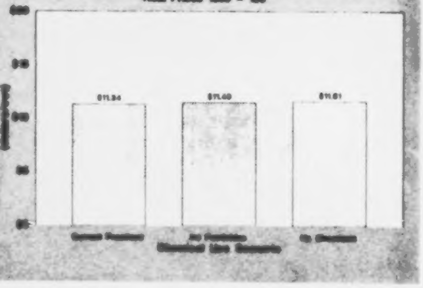
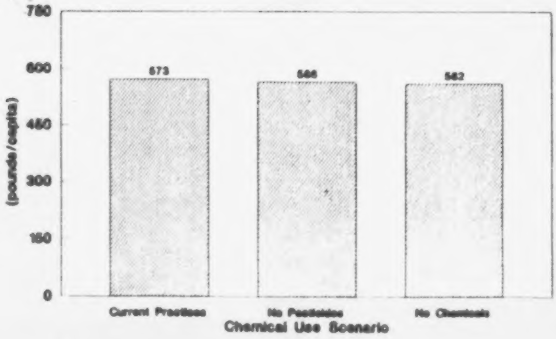


Figure 55

U.S. Milk Consumption Per Capita, 1995-98 Average



CHAPTER FOUR

AGRICULTURE SECTOR AND MACROECONOMIC IMPACTS

The purpose of this chapter is to explain the aggregate impacts of chemical use reduction on the farmers, agribusiness management and employees, and consumers. Analyses of individual crops and livestock enterprises suggest major differences in impacts of reduced chemical use both between these sectors and regionally. One of the uniquenesses of the AG-GEM model is that it allows analysis of regional impacts in the crop sector although not in livestock. Following this sectoral and regional discussion, impacts on agribusiness will be presented. The chapter will end with a presentation of the impacts of chemical use reduction on consumers, overall inflation, and macroeconomic policy. Unless otherwise indicated in this chapter, values are reported in terms of 1989 real dollars.

Macroeconomic Environment

Since chemical use reduction options have a major impact on the macroeconomy, the following assumptions were necessary regarding macroeconomic policy:

- **Inflation.** The Board of Governors of the Federal Reserve System has clearly exhibited a desire to curb inflation whenever it appears to be gathering steam. The fear is that inflationary expectations will grow and be factored into rates of interest, wage negotiations and other prices throughout the economy. The baseline developed in this study assumes that the Federal Reserve System will adopt more restrictive monetary policies when it appears the implicit GNP price deflator shows signs of exceeding an annual rate of 4.5 percent. As a consequence, the implicit GNP price deflator in the baseline never exceeded 4.2 percent over the 1990-1994 time period.

- **Economic Growth.** A twin objective of macroeconomic policymakers is to promote real economic growth in the economy. Many economists have been seeing a recession in the cards for the U.S. economy for several years. Yet, the economy continues to exhibit its longest peace-time expansion. The baseline scenario developed in this study assumes that both monetary and fiscal policy will be moderated whenever the economy's growth appears to fall below an annual rate of growth of 1.5 percent. As a consequence, the rate of growth in real GNP did not fall below 1.7 percent over the 1990-1994 period.

- **Budget deficit.** A third consideration underlying the macroeconomic policies assumed in the baseline is the need to achieve reductions in annual federal budget deficits over the 1990-94 period without causing a significant slowdown in economic growth. To accomplish this, government expenditures over the 1990-94 period were held constant in real terms while personal income taxes were raised moderately. Although the Gramm-Rudman-Hollings targets were not expressly achieved, the lower annual budget deficits in the baseline permitted real interest rates to fall sharply by 1994 and helped lower our nation's nonagricultural trade imbalance. These same general policy parameters were carried out through 1998.

Macroeconomic Impacts

The chemical use reductions examined in this study have unusually large impacts on the general economy. This may surprise those who view agriculture narrowly as farming (2 percent of GNP) but not those who see agriculture as an important part of the nation's food and fiber system (19 percent of GNP). The difference between the 2 percent and the 19 percent represents all of the economic activity associated with the inputs farmers buy, the marketing of farm products, food and fiber processing, exports of farm and related value added food and fiber products, and the wholesaling and retailing functions associated with food and fiber.

The nominal prime rate, for example, would be approximately 12 percent in 1994 under the no chemicals scenario and 10 percent under the no pesticides scenario. This represents a three percentage point and a one percentage point increase over the nominal prime rate projected for 1994 in the baseline, respectively.

The percentage change in the implicit GNP price deflator, a broadly based measure of inflation, would be approximately three percentage points higher in 1994 under the no chemicals scenario and one percentage point higher under the no pesticides scenario than the 1994 level projected in the baseline. Taken together, the rise in the nominal prime rate is largely offset by the rise in inflation, leaving the real prime rate only 0.2 percentage points higher than the baseline under both chemical use scenarios.

> “*While crop producer income would more than double under the no chemical scenario, livestock producer income would decline nearly 50 percent.*”

Despite the elimination of deficiency payments to farmers under both the no chemicals and no pesticides scenarios and our assumption of no increase in government food transfer payments (largely food stamps) to consumers, real government spending in 1994 was higher than projected in the baseline. Much of this increase was due to cost of living adjustments to government transfer payments. This, in turn, translates into higher annual federal budget deficits under both chemical reduction scenarios.

Finally, virtually no difference existed in real GNP in 1994 among the three scenarios (0.5 percent lower than the baseline under the no chemicals scenario and 0.2 percent lower under the no pesticides scenario.)

Agriculture Sector Impacts

Crop Sector

Because of the inelastic demand for crops, small reductions in production result in proportionately larger price increases. This study has indicated relatively large crop yield and production decreases would be associated with reduced chemical use. As a result, large crop price increases would occur. These crop price increases would convert to sharp increases in gross receipts to crop producers. Under the no chemical option, for example, producers' gross income in 1994 for the eight crops studied would increase by 18 percent from the $58.6 billion baseline to $69 billion under no pesticides and by 34 percent from the baseline to $78.6 billion with no chemicals.

Despite cost increases associated with each chemical use reduction scenario, crop producers would experience a sharp increase in average real net farm income from $13.3 billion under the baseline to $20.6 billion with no pesticides and $29.3 billion with no chemicals during the 1995-98 period (Figure 56). Again, this increase in income would assume perfect producer knowledge; instant adjustments in crop mix; specified changes in cropping patterns; and a willingness on behalf of producers to endure a greater intensity of farm management, labor supervision, and labor input.

Livestock Sector

While crop producer income would increase, livestock and poultry producers would suffer from higher feed costs. Real livestock and poultry producer income would decline sharply from $25.7 billion under the current practices baseline to $18.8 billion with no pesticides and $13.2 billion with no chemicals. In other words, crop producers' gain from higher prices would tend to be at the expense of livestock and poultry producers.

That is, while crop producer income would more than double from the baseline of $13.3 billion to $29.3 billion under the no chemical scenario, livestock producer income would decline nearly 50 percent from $25.7 billion under the baseline to $13.2 billion with no chemicals.

Aggregate net farm income would increase marginally from the $39 billion baseline to $39.3 billion with no pesticides and $42.6 billion with no chemicals. With one group of farmers (crop producers) benefitting at the expense of another (livestock producers) and with no compensation, little net economic gain would be achieved by the farming section through reduced chemical use.

Regional Impacts

One of the unique strengths of the AG-GEM model is that the regional impacts of changes in the crop sector can be evaluated in terms of cropping patterns, gross receipts, and net crop income. The production regions designated in the model are indicated in Figure 57.

Cropping Patterns. Table 2 provides a summary of cropping pattern changes associated with reduced chemical use. Detailed regional tables for each policy scenario are contained in Appendix D. The impact of cropping patterns on four of the commodities analyzed by the AG-GEM model are as follows:

- **Soybeans** - The largest and most consistent increase in acres cropped would occur in soybeans with a 19 percent increase from 57.7 million to 68.5 million acres nationally under the no chemical scenario. This increase would be precipitated partially by an effort to gain more nitrogen in rotation with corn and by achieving more favorable price relationships. By far, the largest absolute increase in soybean acreage would occur in the Corn Belt (CB) (6.4 million acres under the no chemical scenario). However, sizable increases in both absolute and percentage terms also would be realized in the Lake States (LS), Northern Plains (NP), Delta, Appalachian (AP), and Southeast (SE) regions, particularly under the no chemical option.

- **Corn** - National corn acreage would increase nearly 7 percent from 69.3 million acres to 74.4 million acres under the no chemical scenario. With no pesticides, the increase would total 12 percent because pesticides are relatively less important in corn. In terms of acreage, corn production would increase the most in the Corn Belt, rising from 35.6 million to 38.6 million acres under the no chemical option. In no other region would corn acreage increase by more than 700,000 acres under the no chemical option.

- **Wheat** - Since wheat has fewer pest problems, wheat acreage would increase the most (16 percent) under the no pesticide scenario. The largest absolute increases would be in the Northern Plains (NP), Southern Plains (SP), and Mountain (MT) regions. Under the no chemical option, all of these regions would reduce wheat production relative to the no pesticide scenario, but total acreage still would increase by 7 percent relative to the current practice baseline.

Table 2. Regional Cropping Patterns for Selected Farm Program Crops, Acres Planted, 1994.

		CB[1]	LS	NP	SP	DELTA	MT	PAC	NE	AP	SE	TOTAL
		Million Acres										
Corn[2]												
	Baseline	35.6	11.7	11.0	1.2	1.1	0.7	0.2	2.9	4.2	0.7	69.3
	No Pesticides	38.6	11.8	12.7	1.6	1.4	1.0	0.2	3.1	5.1	2.4	77.9
	No Chemicals	38.6	12.1	11.3	1.7	1.4	0.9	0.2	3.0	4.9	0.3	74.4
Soybeans												
	Baseline	31.0	5.0	5.9	1.0	5.2	0	0	1.1	5.7	2.8	57.7
	No Pesticides	35.0	5.4	7.4	1.0	5.8	0	0	0.9	5.8	3.1	64.4
	No Chemicals	37.4	5.9	6.6	0.8	6.2	0	0	1.1	6.3	4.2	68.5
Wheat												
	Baseline	4.7	4.5	30.0	11.5	3.6	11.3	4.1	0.4	1.9	2.3	74.3
	No Pesticides	4.3	5.3	35.2	14.0	3.8	13.6	5.1	0.6	1.8	2.5	86.2
	No Chemicals	3.9	5.3	31.8	13.4	4.0	11.8	4.7	0.6	1.8	2.3	79.6
Cotton												
	Baseline	0.1	0	0	6.1	2.4	0.7	1.2	0	0.6	0.4	11.5
	No Pesticides	0.1	0	0	7.8	2.2	0.9	1.4	0	0.5	0.2	13.1
	No Chemicals	0.1	0	0	8.0	2.5	0.9	1.3	0	0.6	0.6	14.0

[1] Regional abbreviations include CB, Corn Belt; LS, Lake States; NP, Northern Plains; SP, Southern Plains; MT, Mountain; PAC, Pacific; NE, Northeast; AP, Appalachia; and SE, Southeast.

[2] Corn is harvested acres for grain only. Cotton, soybeans, and wheat are planted acres.

Table 3. Regional Gross Receipts and Net Income From Eight Crops,[1] 1994 Dollars.

	CB[2]	LS	NP	SP	DELTA	MT	PAC	NE	AP	SE	TOTAL
	Billion Dollars										
Receipts											
Baseline	23.8	7.8	11.6	4.6	3.6	5.3	4.7	2.9	4.1	1.4	69.8
No Pesticides	31.3	9.0	16.2	5.3	3.3	5.8	4.2	3.5	4.6	2.3	86.0
No Chemicals	38.5	12.5	20.8	5.9	3.3	5.4	4.5	4.2	5.2	1.8	103.1
Net Income											
Baseline	8.9	1.6	1.2	0.8	1.1	1.9	2.3	0.8	0.4	0.2	19.2
No Pesticides	16.6	2.7	4.4	1.1	1.1	2.1	2.2	1.3	1.0	0.8	33.3
No Chemicals	24.0	6.3	8.8	1.2	1.0	2.9	2.3	2.0	1.6	0.5	50.6

[1] Eight crops include corn, sorghum, barley, oats, wheat, soybeans, cotton, and hay.

[2] Regional abbreviations include CB, Corn Belt; LS, Lake States; NP, Northern Plains; SP, Southern Plains; MT, Mountain; PAC, Pacific; NE, Northeast, AP, Appalachia; and SE, Southeast.

- **Cotton** - Nationally, cotton acreage would increase 22 percent from 11.5 million acres to 14 million acres when comparing the current practice baseline with the no chemical option. The only region with a large absolute increase in cotton acreage would be the Southern Plains (31 percent). The Southern Plains would experience a 28 percent increase without pesticides. The increase in cotton on the Southern Plains for the reduced chemical options would reflect the comparative advantage of cotton in this region and the relative lack of substitute crops.

Gross Receipts and Net Income. A chemical use reduction policy would not be regionally neutral. Despite substantial increases in prices, receipts and net income would not increase materially in all regions (Table 3). The largest increases in receipts and income would be in the more temperate climates -- the Corn Belt, Lake States, Northern Plains, Northeast and Appalachian regions. The regions in which crop producers notably would receive little or no benefits from chemical use reduction would be the Delta (Arkansas, Mississippi, and Louisiana) and the Pacific region (California, Oregon, and Washington). While regional impact data are not available for the livestock, dairy, and poultry sectors, it can readily be concluded that in the Delta and Pacific regions, the agricultural sector impact of a chemical use reduction strategy would be negative.

The regions with the most notable crop producer net income gains from chemical use reduction would be the Northern Plains (a seven-fold increase), Appalachia (a four-fold increase), the Lake States (a four-fold increase), and the Corn Belt (a three-fold increase). However, each of these regions has substantial dairy, beef, and hog enterprises against which these crop producer gains must be weighed.

Environmental Trade-offs

All of the environmental effects of banning chemicals would not be positive since future soil productivity would be reduced. Both the no pesticide and no chemical options would lead to about a 10 percent increase in cultivated acreage. Under the no pesticide scenario, more than half of the increase would be in row crops as compared to a two-thirds increase with the no chemicals option. Much of the additional acreage would have been set-aside previously by farm programs under the baseline, although some expansion of production to marginal lands also would occur.

Due to the expansion of cultivation, gross soil erosion would increase by more than 10 percent since expansion would occur on marginal land and since land removed from set-aside programs would be the poorest quality land. In addition to increasing sedimentation, land erosion would contribute to the loss of naturally occurring chemicals such as potassium and phosphorus as they moved with the soil into lakes and rivers. The result would be a decrease in future soil productivity.

Land Values

Changes in net income tend to be capitalized into the value of land. This effect was seen very clearly during the 1970s when the higher commodity prices precipitated by the world food crisis drove up farm income. This higher income was then bid into the price of land. A very similar effect occurred in this study. Land values in 1994 would escalate 7.2 percent from a baseline of $809 billion to $867 billion under the no chemical option.

Increasing land values are both a curse and a

Figure 56

Real Net Farm Income for Crop and Livestock Producers, 1995-98

Real Prices 1989 = 100

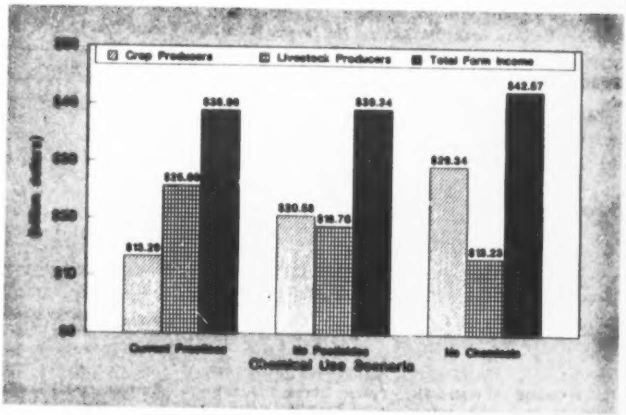
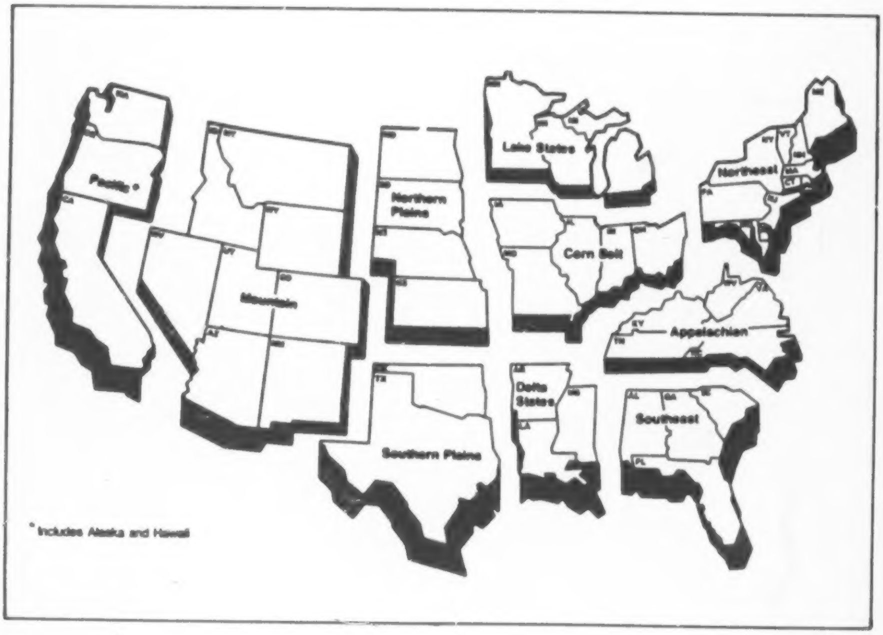


Figure 57

Farm Production Regions



WA
OR
Pacific*
CA
ID
MT
WY
NV
UT
CO
Mountain
AZ
NM
ND
SD
Northern Plains
NE
KS
MN
WI
MI
Lake States
IA
IL
IN
OH
MO
Corn Belt
ME
NY
VT
NH
MA
CT
RI
PA
NJ
DE
MD
Northeast
WV
VA
KY
TN
NC
Appalachian
OK
TX
Southern Plains
AR
MS
LA
Delta States
AL
GA
SC
FL
Southeast
* Includes Alaska and Hawaii

blessing. They are a blessing to the landlords but a curse to the tenants who farm about half of the total acreage. On the other hand, increasing land values are a curse to everyone when they fall as they did during the farm financial crisis of the 1980s.

Agribusiness Impacts

Agribusiness, as used in this study, includes the manufacturers, wholesalers, and retailers of inputs used in farm production and the firms that handle, process, and export wholesale and retail farm products. Agribusiness not only includes the owners and managers of these agribusiness firms, but also the individuals they employ. The agribusiness sector accounts for nearly one-fifth of the U.S. gross national product and employment.

Superficially, it might be presumed that the only agribusiness firms adversely affected by chemical use reduction would be the companies that manufacture and sell agricultural chemicals and nitrogen fertilizer. This is clearly not the case. Firms that have net incomes closely related to the overall volume of products produced would be adversely affected. This directly includes brokers (spot and futures market), merchants, shippers, warehousers, and exporters of U.S. farm products. In other words, the marketing sector for agricultural commodities (as opposed to domestic consumer food products) clearly would be adversely affected by reduced chemical use. While

Figure 58

Chemical Use Reduction Gains and Losses in Billion Dollars by the Purchased Input Agribusiness Sector, No Chemicals Scenario, 1994 (1989 Dollars)

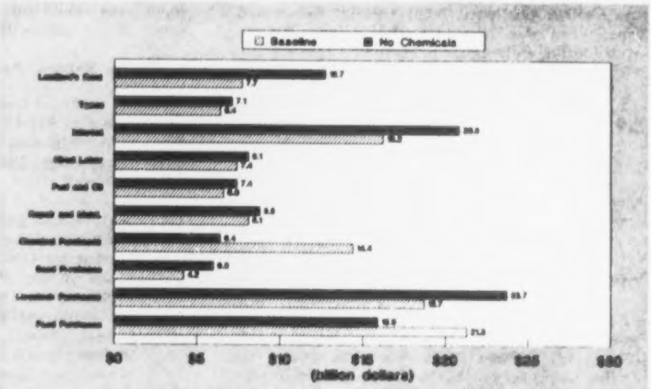
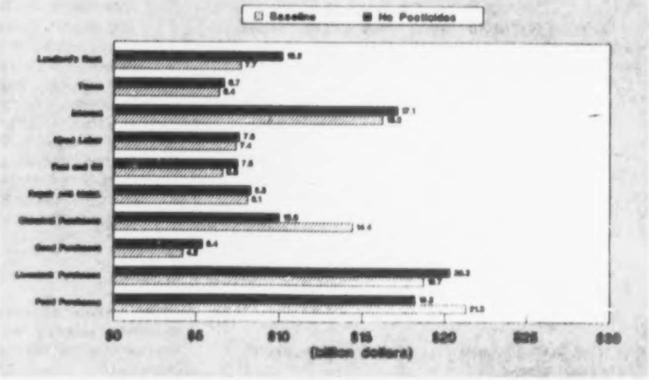


Figure 59

Chemical Use Reduction Gains and Losses in Billion Dollars by the Purchased Input Agribusiness Sector, No Pesticides Scenario, 1994 (1989 Dollars)



this study was only partially able to quantify agribusiness impacts, those impacts were considerably larger than anticipated and some may not have been anticipated at all.

Purchased Inputs

There would be gainers and losers from reduced chemical use in the purchased input sector (Figures 58 and 59). Logically, the firms experiencing the largest losses would be the chemical companies. Under the no chemical scenario, sales of pesticides, fertilizer, and lime would fall by $8 billion from $14.4 billion under the baseline to $6.4 billion (Figure 58). With no pesticides, the drop in chemical sales would be $4.4 billion as sales fell from $14.4 billion to $10 billion (Figure 59).

Another purchased input segment that would experience a large loss would be feed milling. Because of the decline in livestock production -- particularly hogs and cattle feeding -- feed sales would decline $5.4 billion (25 percent) under the no chemical option as sales dropped from $21.3 billion to $15.9 billion (Figure 58). Under the no pesticides option, the decline would be $3.1 billion (15 percent) with sales falling from $21.3 billion to $18.2 billion (Figure 59).

> “*Export volume would decline by about 50 percent with a comparable decline in employment related to the export business, including transportation and handling to export markets.*”

Other purchased input components would experience increased sales under the two reduced chemical scenarios. Notable increases would include:

- Increased seed purchase due to increased acreage and, in some instances, higher seeding rates.
- Increased repairs, maintenance, and petroleum due to more use of mechanical equipment.
- Increased value of livestock purchases due to higher prices.
- Increased interest expenses due to higher interest rates caused by escalated inflation.
- Increased property taxes and rent due to higher land values.

The bottom line would be a net gain for the purchased input sector of $6.7 billion under the no chemicals option and $1.3 billion under the no pesticide option. This net gain would be associated with substantial restructuring of the input component of agribusiness. The net gain also would represent increased costs to the farm sector. Therefore, these results once again suggest that overall farm sector costs would not fall as a result of reduced chemical use as some have inferred, but producer input purchases actually would rise despite less chemical use. Under the no chemical option, total cash farm expenses would increase 6 percent from $110.1 billion to $116.8 billion. Under the no pesticide option, these expenses would increase by 1.2 percent from $110.1 billion to $111.4 billion. Therefore, the notion that reduced chemical use would involve less costly inputs is a misnomer. In fact, this analysis indicates that total input costs would rise although the mix of inputs would change substantially.

Marketing, Storage, Processing, and Export Sector

This sector is considerably more difficult to analyze because AG-GEM does not attempt explicitly to model the marketing and processing segment of the agribusiness sector. Several observations can safely be made, however:

- Agribusiness segments related to the export market would be devastated. Figures 60 and 61 indicate the level of exports for the four major crops during the period 1995-98. The reductions in export levels under the no chemical scenario would be as follows: corn, 47 percent; wheat, 44 percent; soybeans, 53 percent; and cotton, 76 percent. In other words, one could anticipate a decline in export volume of 50 percent. This would mean a comparable decline in employment related to the export business, including transportation and handling to export markets. By a partial equilibrium, comparative static analysis outside the model, employment in export-related activities was estimated to decline by 30 percent (131,781 jobs) under the no pesticide scenario and by 50 percent (217,110 jobs) under the no chemical scenario. The loss in economic activity associated with reduced exports would be $9.4 billion with no pesticides and $14.4 billion with no chemicals.[*]

---

[*] Estimates of export employment and related economic activity were made by Parr Rosson, international trade agricultural economist, Texas A&M University.

Figure 60

Net Exports of Major Grains, 1995-98 Average

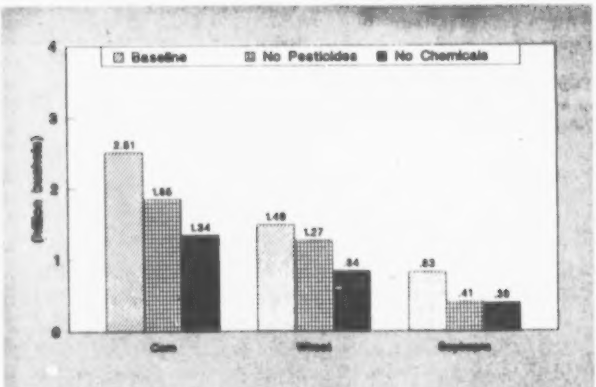
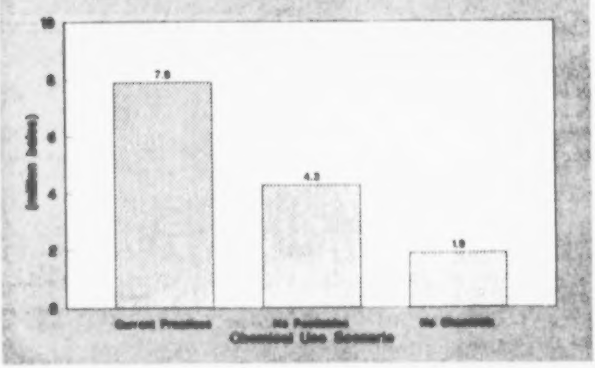


Figure 61

Net Exports of Cotton, 1995-98 Average



- Agribusiness segments related to commodity storage (warehousing) would decline to pipeline levels. Figure 62 indicates the magnitude of decline in stocks for the three major grains grown under the no chemical scenario: 88 percent, corn; 39 percent, wheat; and 79 percent, soybeans. Overall, the results indicate that the quantity of grain in storage would decline by 80 percent. The analysis assumed that stocks relative to domestic use would go no lower than they were during the world food crisis when price volatility became a serious concern. Substantial infrastructure has developed in the United States related to commodity storage. These storage facilities are designed to serve the export market, provide residual food security for the world, and provide support and stability for farm prices under farm programs. One of the impacts of these lower stocks would be greater price instability. In the absence of chemicals, available grain stocks also would be of lower quality because of pest control problems encountered in storage.

- With less exports and lower production, the need for stocks would be reduced in one sense. In another sense, however, the lower stocks also would raise significant questions about U.S. ability to meet international obligations in terms of both food security and international food assistance. With lower production, lower stocks, lower exports, and higher prices, the ability of U.S. taxpayers and consumers to respond to overseas food security needs would be in serious doubt.

Figure 62

Year-Ending Stocks
of Major Grains,
1995-98 Average

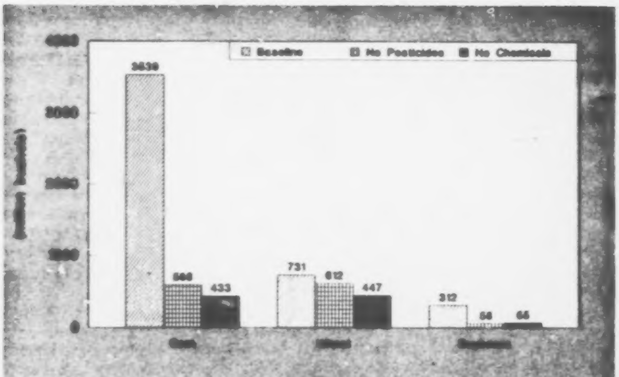


Figure 63

Percentage Change
in the Consumer Price
Index for Food and
Beverages by Chemical
Use Scenario, 1987-94

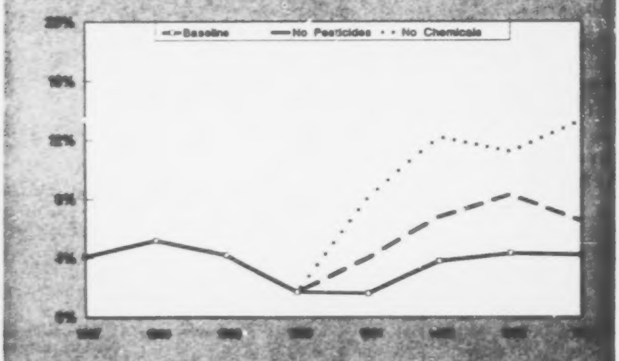
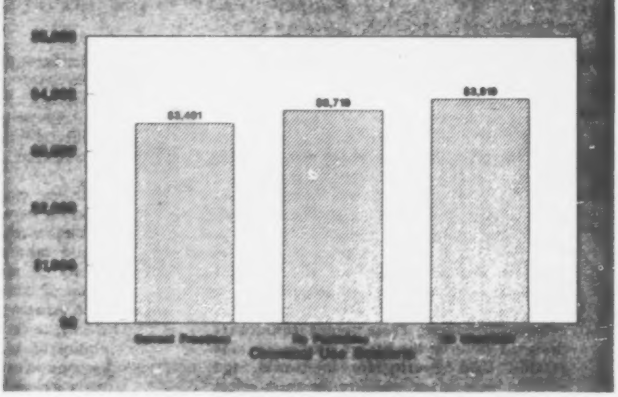


Figure 64

Annual Food Expenditures
Per Household by
Chemical Use Reduction
Scenario, 1995-98

Real Price 1989 = 100



- Impacts of chemical use reduction on processing for domestic consumption can be estimated from the changes in domestic uses of agricultural products. Domestic utilization of crops for processing, crush and industrial uses would fall by approximately one-third. The largest reduction would be in corn. The result would be a more than 30 percent increase in excess capacity and a corresponding reduction in employment for domestic and industrial processing firms. Since many processing costs are fixed, higher unit costs would clearly result. In livestock and poultry, slaughter would be reduced by 15 percent, thus creating excess capacity and higher costs in these agricultural segments as well.

Overall, the marketing, storage, processing, and export sector would be characterized by excess capacity and economic stagnation under either the no pesticide or no chemicals scenario. Their unit costs would rise as substantial fixed expenditures were spread over a smaller volume of business. Business segments such as export, transportation, and storage functions would be particularly hard hit with substantially reduced employment. Other segments would be experiencing reduced demand with little prospect for the rapid recovery and stable growth that have tended to characterize the segment of the agribusiness sector that serves domestic markets.

Rural and Urban Impacts

It is sometimes suggested that reduced chemical use would revitalize rural communities because of the higher farm prices, higher farm incomes, and increased quantities of labor demanded. This study raises serious questions concerning the merits of such speculation. The study has shown that while crop producers benefit, it is at the expense of livestock producers. If the crop and livestock enterprises are on the same farm, one side of the farm benefits at the expense of the other. If crop and livestock enterprises are separated by specialization, one group of farmers tends to be pitted against the other. In either case, no real rural community benefits result.

Of greater significance are the declines in certain agribusiness input components and in marketings within the rural communities. Farm supply stores, feed millers, and grain elevators are significant employers in agriculture-dependant rural communities. The clear evidence from this study is that their sales would decline significantly. This decline would be partially offset by an increase in employment associated with increased use of machinery resulting from greater cultivation to control pests.

Agricultural employment is not just a rural phenomenon. Many of the 18-20 percent of the population that work in the food system live and are employed in urban areas. Export related jobs tend to be concentrated in major agricultural ports such as New Orleans, Houston, Long Beach, Portland, Seattle or Baltimore. The 30 percent decline in domestic crop utilization for processing and the 15 percent reduction in livestock slaughter would be revealed in reduced employment in food processing and retailing establishments, most of which are located in urban areas.

Inflation and Consumer Impacts

Inflationary pressures would be rising under both chemical reduction scenarios. The implicit GNP price deflator in 1994 would be approximately 9 percent higher under the no chemical scenario than under the baseline. This is due, in part, to the 33 percent increase in the CPI for food under the no chemical scenario. The annual rate of inflation in 1994, as measured by the percent change in the implicit GNP price deflator, would be 8.2 percent under the no chemical scenario. This represents a 4.3 percentage point increase or about double the inflation in 1994. It is clearly higher than the 3.9 percent upper limit target assumed in developing the baseline. Such an increase in inflation would surely invite a response from the Federal Reserve System in the form of tighter monetary policy that would slow growth of the economy, and the early 1980s demonstrate that an increase would be particularly harsh on capital-intensive sectors like agriculture.

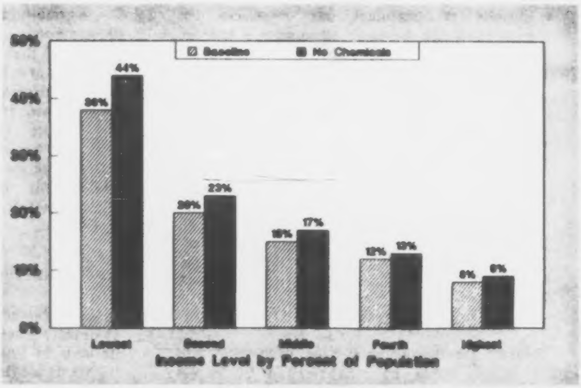
The rate of change in the CPI for food is indicated in Figure 63. As soon as chemical use restrictions were implemented in 1991, a sharp increase in food prices would occur. Over the period 1991-94, the food CPI would increase at a rate ranging from 11.2 percent in 1993 to 13.3 percent in 1994.

> “*Domestic utilization of crops for processing, crush and industrial uses would fall by about one-third as a result of chemical use reduction. The result would be a more than 30 percent increase in excess capacity and a corresponding reduction in employment.*”

As a general rule, double digit increases in food prices (10 percent or more) are a signal of serious consumer/political problems. This was the case in 1973 and 1974 when food price inflation reached 14.5 and 14.4 percent, respectively. In reaction, food prices

Figure 65

Percent of Income Spent on Food by Level of Household Income and Chemical Use Reduction Scenario, 1995-98



were frozen by price controls and wheat exports were embargoed. In 1978 and 1979, the food CPI increased at a rate of 10 percent and 10.9 percent, respectively. This was a contributing factor to embargo decisions in the late 1970s.

The point is clear. Chemical use reduction policies have a definite potential for triggering inflationary pressures that have both economic and political implications. This reality may be seen even more clearly by evaluating the impact of these increases in inflation on consumer food expenditure.

Increased Household Food Expenditures

With the no pesticide or no chemical scenarios, substantial increases would occur in the consumers' weekly food bill and in the proportion of income spent on food for lower income consumers.

The analysis indicates that over the period 1995-98, under the no chemical scenario, the average household of 2.52 persons would spend an additional $8.24 per week on food (1989 dollars). For the middle income consumer, this amounts to a 12 percent increase in the weekly food bill -- from $67.13 per week to $75.37 per week (Figure 64). For the no pesticide scenario, the increase in weekly food costs would be $4.39 per household. The middle income household in 1989 under the no pesticide scenario would spend 6.5 percent more for food -- from $67.13 per household per week to $71.52.

Lower income consumers spend a larger proportion of their income on food. ERS/USDA provides data on the share of income spent on food by income segments of the population. Their data indicate that the 20 percent of the households having the lowest incomes spend 38 percent of their income on food. Under the no chemical scenario, these households would spend 44 percent of their income on food (Figure 65). The second 20 percent of the population spends 20 percent of its income on food but would spend 23 percent under the no chemical scenario. The middle income segment of the population would increase its share of income spent on food from 15 percent to 17 percent.

Chemical use reduction policy therefore affects all segments of the population -- farmers, agribusiness management and employers, and consumers both at home and abroad. As a result, great care needs to be taken in charting a chemical use reduction policy.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND IMPLICATIONS

The major objective of this study was to determine the impacts of chemical use reduction on farmers, agribusiness management and employees, consumers, and the general economy. Leading crop scientists utilized the research and expertise of over 140 other soil and crop scientists to provide estimates of the impacts of chemical use reduction on yields of corn, soybeans, wheat, cotton, rice, peanuts, and sorghum in each major U.S. production region. Yield impacts were provided independently for zero use of herbicides, insecticides and fungicides (except seed treatments), inorganic nitrogen fertilizer, and combinations thereof (including no pesticides and no chemicals). In providing these estimates, the crop scientists included adjustments in cultural practices that were considered to be consistent with optimal management under conditions of restricted chemical use. Farm management economists calculated the costs incurred by farmers utilizing the specified cultural practices and yields for each chemical use reduction scenario.

Utilizing the scientists' estimates, substantial reductions in yields and increases in unit costs of production would be found in all crops:

- U.S. corn yields would fall 32 percent with no pesticides and 53 percent with no chemicals. In response, total economic costs per bushel would rise 27 percent with no pesticides and 61 percent with no chemicals.
- U.S. soybean yields would decline 37 percent due to no pesticides and no chemicals while total economic costs per bushel would increase 45 percent.
- U.S. wheat yields would decline 25 percent with no pesticides and 38 percent with no chemicals while total economic costs per bushel would increase 33 percent and 50 percent, respectively.
- Cotton yields would drop 39 percent with no pesticides and 62 percent with no chemicals while total economic costs per pound would rise 54 percent and 118 percent, respectively.
- Rice yields would fall 57 percent under no pesticides while costs per cwt would double. With no chemicals, the rice yield would decline by 63 percent, and the cost would increase 133 percent.
- Peanut yields would plummet 78 percent with no pesticides and no chemicals while costs per pound would more than triple.

Southern production regions with more prolific weeds, insects, and fungi generally would be more adversely affected by reduced chemical use than the more temperate Northern climates. For example, soybean yields would decline 33 percent in the North Central region but would drop sharply to 51 percent in the Delta. As a consequence, total economic costs would increase by only 37 percent in the North Central region but would rise to 90 percent in the Delta.

Reduced production would mean sharply higher prices for crop producers, prices that generally would more than offset the higher costs. For example, under the no chemical scenario, real corn prices would double; soybeans would increase 150 percent; wheat would increase 24 percent; rice would more than double; cotton would double; and peanuts would rise 147 percent. Therefore, crop producer incomes would rise by 120 percent.

Due to higher feed costs, however, livestock producer income would fall 50 percent, thus offsetting most of the gains generated in the crop sector. Therefore, one farmer's gain was another's loss.

Higher prices also would mean sharply reduced export demand. Under the no chemical scenario, grain export volume (corn, wheat, and soybeans), as well as cotton exports, would decline by about 50 percent. This reduction would result in an estimated 217,000 fewer jobs in occupations related to exports, and economic activity would decrease by $14 billion. With no pesticides, grain export volume would decline 36 percent; cotton would decline 46 percent; and export employment would drop by 131,000 jobs.

> "*Food prices would exceed double digit levels, a phenomenon that has not occurred since the embargo and food price control years of the 1970s.*"

Besides export-oriented firms, other agribusiness firms would suffer severely reduced sales, particularly chemical and fertilizer companies, feed mills, and commodity warehouse facilities. For domestic uses, processing related to crops would decline by about one-third while livestock and poultry slaughter would drop by 15 percent. The agribusiness sector, which employs about 20 percent of the U.S. work force, would experience reduced employment in already declining rural communities as well as in urban areas where port facilities are located and most of the food processing takes place.

Higher farm prices resulting from reduced chemical use would aggravate inflationary pressures. Food prices would exceed double digit levels in 1991-94, a phenomenon that has not occurred since the embargo and food price control years of the 1970s.

Using the no pesticide scenario, consumers would spend an additional $228 annually on food for each household and $428 if the no chemicals scenario were applied. This would be a particular burden for the lower 20 percent of the population that already spends 38 percent of its income on food and would be spending 44 percent if the no chemicals scenario were used.

The main implication of this study is that pursuit of reduced chemical use policy involves a number of economic, social, real, and perceived trade-offs. The issues are complex and the stakes are high. Among the major trade-offs are the following:

- Perceived and/or real environmental concerns vs. the potential for significant economic impacts on the U.S. economy and the food and fiber industry in terms of increased costs, reduced competitiveness, and increased risk.
- Protectionist policies spawned by reduced competitiveness vs. an open trade policy.
- Higher production costs for the U.S. farmers forced to reduce chemical use vs. greater chemical use abroad as other countries increase production to take advantage of higher U.S. crop prices and reduced U.S. exports.
- Low food vs. increased food costs impacting on the poor.
- Increased soil erosion vs. reduced chemical use.
- Crop vs. livestock producers.
- Cold regions less favorable to the growth of pests vs. warm and humid regions.

The existence of these trade-offs suggests a need for more information before making further policy decisions regarding chemical use reduction. Increased research is needed to find effective and efficient substitutes for chemical inputs with the potential for adverse environmental impacts. Educational and farm management aids, such as integrated pest management systems, could serve as a means of assuring that chemical use is consistent with needs.

APPENDICES

APPENDIX A
Scientists and Research Publications Providing Data for Chemical Use Reduction Analyses

CORN & SOYBEAN SOURCES

Lead Plant Scientist:
R.G. Hoeft, Agronomy, University of Illinois

Lead Agricultural Economist:
Earl Swanson, Agricultural Economics, University of Illinois

Scientists Contacted:
Stu Pettygrove, Agronomy, University of California-Davis
Larry W. Mitich, Agronomy, University of California-Davis
Mike Daves, Plant Pathology, University of California-Davis
D. Pennington, Agronomy, Texas A&M University
Paul Bowman, Agronomy, Texas A&M University
Pat Morrison, Entomology, Texas A&M University
Ken Frank, Agronomy, University of Nebraska
Alex Martin, Agronomy, University of Nebraska
Zebe Mayo, Entomology, University of Nebraska
Dave Wysong, Plant Pathology, University of Nebraska
Hunter Follet, Agronomy, Colorado State University
Phil Westra, Agronomy, Colorado State University
Ford Baldwin, Agronomy, University of Arkansas
D. Sanders, Agronomy, Louisiana State University
Jim Tynes, Entomology, Louisiana State University
Nate Hartwick, Agronomy, Penn State University
Dennis Calvin, Entomology, Penn State University
Allen Bandel, Agronomy, University of Maryland
Ron Ritter, Agronomy, University of Maryland
Lee Helman, Entomology, University of Maryland
Joe Touchton, Agronomy, Auburn University
Mike Patterson, Agronomy, Auburn University
Ron Smith, Entomology, Auburn University
Barry Jacobson, Plant Pathology, Auburn University
Owen Plank, Agronomy, University of Georgia
Mike French, Agronomy, University of Georgia
Don Canerday, Entomology, University of Georgia
Jack Beard, Agronomy, North Carolina State University
Bill Lewis, Agronomy, North Carolina State University
John Van Dyne, Entomology, North Carolina State University
Greg Evanlow, Agronomy, Virginia Polytechnic Institute
Scott Haygood, Agronomy, Virginia Polytechnic Institute
Regis Voss, Agronomy, Iowa State University
Mike Owen, Agronomy, Iowa State University
Marlin Rice, Entomology, Iowa State University
Larry Bundy, Soils, University of Wisconsin
Ron Doersch, Agronomy, University of Wisconsin
John Wedberg, Entomology, University of Wisconsin
Jay Johnson, Agronomy, Ohio State University
Mark Loux, Agronomy, Ohio State University
Howe Wilson, Entomology, Ohio State University
Pat Lipps, Plant Pathology, Ohio State University
E.L. Knake, Agronomy, University of Illinois
Kevin Steffey, Entomology, University of Illinois
Walker Kirby, Plant Pathology, University of Illinois

Articles Cited:

______. 1987. Farm Management Manual. University of Illinois Coop. Ext. Service, Department of Agricultural Economics. AE-4473e.

______. 1986. Guide for adjusting custom rates and machine rental rates for 1986-87. Farm Economics Facts and Opinions. Department of Agricultural Economics, University of Illinois.

U.S. Department of Agriculture. 1988. Agricultural Statistics.

U.S. Department of Agriculture. 1988. Agricultural Resources, Situation and Outlook Report, Economic Research Service, AR-9.

WHEAT & BARLEY SOURCES

Lead Plant Scientist:
Dallas Peterson, Agronomy, Kansas State University

Lead Agricultural Economist:
Larry Langemeier, Economics, Kansas State University

Scientists Contacted:
Carl Fanning, Soils Specialist, North Dakota State University
Douglas Jardine, Plant Pathologist, Kansas State University
Russel Karow, Agronomist, Oregon State University
Ray Lamond, Soil Fertility Specialist, Kansas State University
Marcia McMullen, Plant Pathologist, North Dakota State University
John Nalewaja, Weed Science Professor, North Dakota State University
Dave Regehr, Weed Specialist, Kansas State University
Phil Stahlman, Weed Science Researcher, Hays Exp. Stn., Hays, Kansas
Ed Vasey, Soil Fertility Specialist, North Dakota State University
Dave Whitney, Soil Fertility Specialist, Kansas State University
Gerald Wilde, Entomology Professor, Kansas State University

Articles Cited:

Chandler, J.M., A.S. Hamill, and A.G. Thomas. 1984. Crop losses due to weeds in Canada and the United States. Weed Science Society of America Special Review.

Delvo, H.W. 1988. Agricultural Resources: Inputs, situation and outlook report. USDA-ERS:AR-9.

Dexter, A.G., J.D. Nalewaja, D.D. Rasmusson, and J. Buchli. 1981. Survey of wild oats and other weeds in North Dakota, 1978 and 1979. North Dakota Ag. Exp. Stn. Res. Report No. 79.

Langemeier, L.N. 1989. 1989 KSU Farm Management Guides.

Lamond, R.E., and D.E. Kissel. 1989. Kansas Fertilizer Research, 1988. Kansas State University Ag. Exp. Stn. Rep. of Progress 561.

LeClerg, E.L. 1965. Losses in Agriculture. USDA-ARS Agriculture Handbook No. 291.

McMullen, M.P., A.G. Dexter, J.D. Nalewaja, W. Hamlin, and K. Davison. 1985. Pesticide use on major crops in North Dakota, 1984. North Dakota State Univ. Agronomy Report 3.

Nilson, E.B., and M.E. Johnson. 1980. Kansas 1978 pesticide usage. Report from Kansas Crop and Livestock Reporting Service and Kansas State University Coop. Ext. Service.

Nilson, E.B. File materials. Yield losses from weeds in Kansas wheat estimated at 12% in 1984.

Whitney, D.A., and D.E. Kissel. Optimum nitrogen rates for wheat. Kansas State Univ. Coop. Ext. Service.

Wheat cost-return budget information for the following states: Alabama, Arizona, Illinois, Indiana, Iowa, Kansas, Missouri, Montana, Nebraska, New Mexico, New York, North Dakota, Oklahoma, Oregon, and Pennsylvania.

USDA, Kansas State Board of Agriculture, " Kansas Custom Rates, 1988," January 1989.

Langemeier, L.N., 1989. "Machinery Tillage Costs Program," Department of Agricultural Economics, Kansas State University.

WHEAT & BARLEY SOURCES (continued)

Plant Scientist:
John C. Gardner, Agronomy, North Dakota State University

Agricultural Economist:
Cole Gustafson, Agricultural Economics, North Dakota State University

---

Articles Cited:

Gardner, J.C. Impact of Reduced Chemical Use: Agronomic Analysis in Wheat and Barley. North Dakota State University.

Bailey, L.D. 1982. Nitrogen fixation and legumes in crop rotation. Agdex 537/121. Ag Canada, Brandon, Manitoba.

Ball, W.S. 1987. Crop Rotations for North Dakota. NDSU Ext. Bull. EB-48. NDSU. Fargo, ND.

Haas, H.J., and C.E. Evans. 1957. Nitrogen and carbon changes in Great Plains soils as influenced by soil treatments. USDA Tech Bull 1164.

Holland, E.A., and D.C. Coleman. 1987. Litter placement effects on microbial and organic matter dynamics in an agroecosystem. Ecology 68:425-433.

Kirshenmann, F. 1988. Switching to a sustainable system. Northern Plains Sustainable Agriculture Society. Windsor, ND.

National Research Council. 1989. Alternative Agriculture. National Academy Press, Washington D.C.

Power, J. 1987. Legumes: Their potential role in agricultural production. Amer. Journ. Alt. Ag. 2(2):69-73.

Sarvis, J.T., and J.C. Thysell. 1936. Crop rotation and tillage experiments at the Northern Great Plains field station. Mandan, ND. USDA Tech Bull No. 536.

Sims, J.R. 1989. CREST farming: A strategy for dryland farming in the Northern Great Plains-Intermountain Region. Journ. Alt. Ag. (IN PRESS)

Smika, D.E. 1970. Summer fallow for dryland winter wheat in the semi-arid Great Plains. Agron J. 62:15-17.

Van Dyne, D.L., and C.B. Gilbertson. 1978. Estimating U.S. Livestock and Poultry Manure and Nutrient Production. USDA Economics, Statistics, and Cooperative Service. Washington D.C.

Fuller, E.I., and M.F. McGuire. 1988. Minnesota Farm Machinery Economic Cost Estimates for 1988. AG-FO-2308, University of Minnesota Extension Service, St. Paul.

Kletke, D.D. 1979. Operation of the Enterprise Budget Generator. Ag. Exp. Stat. Res. Rpt. P-790, Stillwater, OK.

National Farm and Power Equipment Dealers Assoc. Official Guide. St. Louis, MO, Spring 1989.

U.S. Dept. of Agriculture. 1989. 1987 Wheat and Barley Budgets. Economic Research Service, Washington, D.C.

WHEAT & BARLEY SOURCES (continued)

Plant Scientist:
Russ Karow, Crop Science, Oregon State University

Agricultural Economist:
Larry Lev, Agricultural and Resource Economics, Oregon State University

---

Scientists Contacted:
Tim Cross, Agricultural Economist, Oregon State University
Baird Miller, Cereals Specialist, Washington State University
Mike Stolz, Crops Agent, Umatilla County, Oregon
Neil Christensen, Soil Scientist, Oregon State University
John Hart, Soil Fertility Specialist, Oregon State University
Glenn Fisher, Entomologist, Oregon State University
Hugh Homan, Entomologist, University of Idaho
Chris Mundt, Cereal Pathologist, Washington State University
Brad Brown, Soil Scientist/Specialist, University of Idaho
Don Wysocki, Soil Scientist/Specialist, Oregon State University
Don Rydrych, Weed Researcher, Oregon State University
Alex Ogg, Weed Researcher, Washington State University

Grower Review Panel:
Jim Harris, Pendleton, Oregon
Clinton Reeder, Pendleton, Oregon
George Struthers, Prescott, Washington
Chris Shaffer, Walla Walla, Washington
Doug Scoville, Potlatch, Idaho

Articles Cited:

Karow, Russ, and Tim Cross. November 20, 1989. Input reduction impact projections for PNW wheat and barley. Oregon State University Extension.

Bolton, F.E., S.F. Miller, M. Taylor, and D.M. Glenn. 1988. Wheat plan - a climate-yield-nitrogen computer program to evaluate wheat fertilization strategies for North Central Oregon. OSU ES pilot release publication.

Caplan, A., H. Hinman, T. Hoffmann, and D. McCool. 1987 Crop Enterprise Budgets, Selected Tillage Systems, Eastern Whitman County, Washington. Extension Bulletin 1437. Washington State University Extension. March
1987.

Colombia Basin Ag. Research Center Annual Reports, 1976 to present.

Cross, T., R. Karow, and M. Stolz. Enterprise Budget: Wheat, North Central Region. EM8368. Oregon State University Extension. February 1988.

Kirby, E.M. 1986. Soil moisture and wheat yield response from annual legumes in the PNW. M.S. diss. Washington State University, Pullman, Washington.

Macnab, S., M. Stolz, B. Tuck, J. Murphy, and T. Cross. Dryland Wheat Production and Marketing Costs in Oregon's Colombia Plateau, 1988-90. SR820. Oregon State University Extension. May 1989.

Miller, B. 1989. Data from long-term dryland and sprinkler irrigated trails at Lind, WA. Personal communication.

Rasmussen, P.E., H.P. Collins, and R.W. Smiley. 1989. Long-term management effects on soil productivity and crop yield in semi-arid region of Eastern Oregon. Oregon State University AES Bulletin 675.

Rinehold, J.W., and J.M. Witt. 1989. Oregon pesticide use estimates for 1987. Oregon State University Ext. Service Special Report 843.

Rydrych, D. 1989. Data from eight site years of fertilizer herbicide elimination trials in Eastern Oregon. Personal communication and unpublished project reports (1982-84).

Smathers, R., and C.W. Gray. 1987 South Central Idaho Crop Enterprise Budget: Winter Wheat-Soft White. MS102-14. University of Idaho Extension. 1987.

Smathers, R., N. Rimbey, and D. Bolz. 1987 Southwestern Idaho Crop Enterprise Budgets: Winter Wheat. MS104-14. University of Idaho Extension. 1987.

Taylor, M., T. Cross, and G. Gingrich. Enterprise Budget: Winter Wheat, Willamette Valley Region. Oregon State University Extension. November 1989.

U.S. Department of Commerce, Bureau of the Census. 1987 Census of Agriculture, Oregon, Washington, and Idaho State and County Data. April 1989.

Wilson, H., L. Bauscher, and G. Willet. 1985 Crop Enterprise Budgets for Walla Walla County, Washington. Extension Bulletin 131. Washington State University Extension. January 1985.

GRAIN SORGHUM SOURCES

Lead Plant Scientist:
John F. Stone, Agronomy, Oklahoma State University

Lead Agricultural Economist:
Harry P. Mapp, Agricultural Economics, Oklahoma State University

---

Scientists Contacted:
Samuel Geleta, Research Associate, Oklahoma State University
Steven E. Hawkins, Extension Specialist in Grain Sorghum, Oklahoma State University
Gordon V. Johnson, Professor of Soil Fertility, Oklahoma State University
F.E. Legrand, Director, Crop Improvement Association, Stillwater, Oklahoma
Donald S. Murray, Professor of Weed Science, Oklahoma State University
H.E. Reeves, Professor of Agronomy, Panhandle State University
Loren M. Rommann, Professor of Pasture Management, Oklahoma State University
B.B. Tucker, Professor of Soil Fertility, Oklahoma State University
R.L. Westerman, Professor of Soil Fertility, Oklahoma State University
Mark E. Hodges, Area Extension Agronomist, Texas Co., Guymon, Oklahoma
William Massey, Area Extension Entomologist, Texas Co., Guymon, Oklahoma

PEANUT SOURCES

Lead Plant Scientist:
John Beasley, Agronomy, University of Georgia

Lead Agricultural Economist:
Fred C. White, Agricultural Economics, University of Georgia

Scientists Contacted:
W. Carroll Johnson, USDA, Tifton, Georgia
Albert Culbreath, University of Georgia, Coastal Plain Experiment Station, Tifton, Georgia
John Wilcut, Virginia Polytechnic Institute, Tidewater Research Center, Holland, Virginia
Pat Phipps, Virginia Polytechnic Institute, Tidewater Research Center, Holland, Virginia
Ames Herbert, Virginia Polytechnic Institute, Tidewater Research Center, Holland, Virginia
Rick Brandenberg, North Carolina State University, Raleigh, North Carolina
James Grichar, Texas A&M University, Yoakum, Texas
Chip Lee, Texas A&M University, Stephenville, Texas

COTTON SOURCES

Lead Plant Scientist:
Ray Frisbie, Entomology, Texas A&M University

Lead Agricultural Economist:
Ron Lacewell, Agricultural Economics, Texas A&M University

Scientists Contacted:
G.A. Carlson, Agricultural Economics, North Carolina State University
Ron H. Smith, Entomologist, Alabama Cooperative Extension Service
Roy Smith, Entomologist, Auburn University
Jim Novak, Agricultural Economics, Auburn University
Christopher Sansone, Entomologist(PM), Texas A&M University
John W. Norman, Jr., Entomologist(PM), Texas A&M University

Robert B. Metzer, Agronomist, Texas A&M University
Roy D. Parker, Entomologist, Texas A&M University
John Bremer, Weed Specialist, Texas A&M University
Steve Livingston, Agronomist, Texas A&M University
John Matocha, Research Agronomist, Texas A&M University
James Supak, Agronomist, Texas A&M University
Emory Boring, Entomologist, Texas A&M University
James Leser, Entomologist, Texas A&M University
Mike Chandler, Weed Scientist, Texas A&M University
Jackie Smith, Agricultural Economist, Texas A&M University
Merritt Taylor, Agricultural Economist, Texas A&M University
Bob Head, Entomologist, Mississippi State University
Mark Cochran, Agricultural Economist, University of Arkansas
Jake Phillips, Entomologist, University of Arkansas
Don Johnson, Entomologist, University of Arkansas
James C. Wade, Economist, University of Arizona
Peter B. Goodell, Area IPM Advisor/IPM Extension Coordinator, University of California
Walt Bentley, Entomology Farm Advisor, Kern County, California
Tom Kerby, Cotton Specialist, University of California
Jeff Silvertooth, Plant Scientist, University of California
Leon Moore, Plant Scientist, University of Arizona
Stephanie Johnson, Farm Advisor, Tulare County, California
Lowell Zelinski, Farm Advisor, Fresno County, California

RICE SOURCES

Lead Plant Scientist:
Steve Linscombe, Rice Research Station, Crowley, Louisiana

Lead Agricultural Economist:
Joe Musick, Rice Research Station, Crowley, Louisiana

Scientists Contacted:
John Holt, Rice Research Station, Crowley, Louisiana
Marlin Brandon, Director, Rice Research Station, Biggs, California
Jim Hall, Rice Agronomist, Cooperative Extension Service, University of California-Davis

APPENDIX B

Appendix Table B1. Baseline Annual Corn Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	72.3	79.2	77.9	78.0	77.3	76.8
Yield Per Planted Acre (Bu.)	104.1	106.1	106.7	107.1	107.6	107.9
Acreage Harvested (Mil. Ac.)	64.8	71.4	70.3	70.3	69.7	69.3
Yield Per Harvested Acre (Bu.)	116.2	117.7	118.3	118.8	119.3	119.7
Supply (Mil. Bu.): *						
Stock Carryin	1930.0	1480.0	2003.5	2326.3	2554.4	2604.6
Current Production	7527.0	8403.1	8312.3	8352.4	8310.7	8288.5
Total Supply	9457.0	9883.1	10315.8	10678.7	10865.0	10893.2
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	4400.0	4674.9	4747.8	4818.3	4856.4	4857.9
Domestic Use for Food, Gasohol and Other Uses	1305.0	1008.3	1088.8	1146.9	1191.7	1227.2
Net Exports	2275.0	2196.4	2152.9	2159.1	2312.3	2326.0
Total Disappearance	7980.0	7879.6	7989.5	8124.3	8360.4	8411.0
Stock Carryout	1480.0	2003.5	2326.3	2554.4	2604.6	2482.1
Farm Prices:						
Price of Corn ($/Bu.) *	2.34	2.34	2.37	2.40	2.51	2.68
Real Price of Corn ($/Bu., 1989 $)	2.34	2.25	2.19	2.14	2.16	2.21
Farm Program Features:						
CCC Loan Rate ($/Bu.)	1.60	1.61	1.53	1.50	1.50	1.45
Target Price ($/Bu.)	2.90	2.81	2.83	2.84	2.85	2.87
Program Yield (Bu.)	105.00	105.00	105.00	105.00	105.00	105.00
ARP Set-aside Rate (%)	10.00	10.00	[illegible]	15.00	15.00	15.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Values.

Addendum:

	1989	1990	1991	1992	1993	1994
Total Ending Stock-to-Total Use Ratio	0.1855	0.2543	0.2912	0.3144	0.3153	0.2951

Appendix Table B2. No Pesticide Annual Corn Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	72.3	79.2	83.4	82.5	81.8	86.5
Yield Per Planted Acre (Bu.)	104.1	106.1	89.3	82.9	79.1	86.4
Acreage Harvested (Mil. Ac.)	64.8	71.4	75.2	74.4	73.7	78.0
Yield Per Harvested Acre (Bu.)	116.2	117.7	99.0	91.9	87.7	95.8
Supply (Mil. Bu.): *						
Stock Carryin	1930.0	1480.0	2003.5	1567.3	782.3	511.2
Current Production	7527.0	8403.1	7451.5	6843.5	6463.9	7475.3
Total Supply	9457.0	9883.1	9455.1	8410.8	7246.2	7986.6
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	4400.0	4674.9	4715.5	4681.7	4125.2	4466.9
Domestic Use for Food, Gasohol and Other Uses	1305.0	1008.3	1066.5	1085.9	987.1	1080.8
Net Exports	2275.0	2196.4	2105.8	1860.9	1622.6	1717.4
Total Disappearance	7980.0	7879.6	7887.8	7628.5	6734.9	7265.1
Stock Carryout	1480.0	2003.5	1567.3	782.3	511.2	721.5
Farm Prices:						
Price of Corn ($/Bu.) *	2.34	2.34	2.47	2.95	4.81	3.40
Real Price of Corn ($/Bu., 1989 $)	2.34	2.25	2.28	2.60	4.04	2.73
Farm Program Features:						
CCC Loan Rate ($/Bu.)	1.60	1.61	1.53	1.50	1.50	1.45
Target Price ($/Bu.)	2.90	2.81	2.83	2.84	2.85	2.87
Program Yield (Bu.)	105.00	105.00	105.00	105.00	105.00	105.00
ARP Set-aside Rate (%)	10.00	10.00	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Values.

Addendum:

	1989	1990	1991	1992	1993	1994
Total Ending Stock-to-Total Use Ratio	0.1855	0.2543	0.1987	0.1026	0.0759	0.0993

Appendix Table B3. No Chemical Annual Corn Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	72.3	79.2	81.7	80.6	87.8	82.5
Yield Per Planted Acre (Bu.)	104.1	106.1	78.7	70.9	71.0	65.3
Acreage Harvested (Mil. Ac.)	64.8	71.4	73.7	72.7	79.2	74.5
Yield Per Harvested Acre (Bu.)	116.2	117.7	87.2	78.6	78.7	72.4
Supply (Mil. Bu.): *						
Stock Carryin	1930.0	1480.0	2003.5	914.8	470.8	491.1
Current Production	7527.0	8403.1	6425.8	5713.5	6232.7	5393.9
Total Supply	9457.0	9883.1	8429.3	6628.2	6703.5	5885.1
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	4400.0	4674.9	4319.7	3828.2	3990.4	3501.1
Domestic Use for Food, Gasohol and Other Uses	1305.0	1008.3	1215.0	879.6	912.0	827.8
Net Exports	2275.0	2196.4	1979.8	1449.7	1309.9	1123.3
Total Disappearance	7980.0	7879.6	7514.5	6157.4	6212.3	5452.2
Stock Carryout	1480.0	2003.5	914.8	470.8	491.1	432.9
Farm Prices:						
Price of Corn ($/Bu.) *	2.34	2.34	3.02	6.44	5.32	7.90
Real Price of Corn ($/Bu., 1989 $)	2.34	2.25	2.75	5.54	4.30	6.00
Farm Program Features:						
CCC Loan Rate ($/Bu.)	1.60	1.61	1.53	1.50	1.50	1.45
Target Price ($/Bu.)	2.90	2.81	2.83	2.84	2.85	2.87
Program Yield (Bu.)	105.00	105.00	105.00	105.00	105.00	105.00
ARP Set-aside Rate (%)	10.00	10.00	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Values.

Addendum:

	1989	1990	1991	1992	1993	1994
Total Ending Stock-to-Total Use Ratio	0.1855	0.2543	0.1217	0.0765	0.0791	0.0794

Appendix Table B4. Baseline Annual Soybean Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	60.5	60.3	58.2	57.7	57.3	57.7
Yield Per Planted Acre (Bu.)	31.9	33.4	33.6	33.9	34.2	34.5
Acreage Harvested (Mil. Ac.)	59.1	58.9	56.9	56.4	56.0	56.4
Yield Per Harvested Acre (Bu.)	32.6	34.1	34.4	34.7	35.0	35.3
Supply (Mil. Bu.): *						
Stock Carryin	182.0	335.0	389.0	386.8	371.6	332.0
Current Production	1927.0	2011.3	1956.5	1956.4	1961.6	1991.5
Total Supply	2109.0	2346.3	2345.6	2343.2	2333.3	2323.5
Disappearance (Mil. Bu.): *						
Domestic Use for Crush and Other Uses	1184.0	1230.0	1247.9	1258.0	1261.1	1256.7
Net Exports	590.0	727.3	710.9	713.5	740.3	793.4
Total Disappearance	1774.0	1957.3	1958.8	1971.6	2001.5	2050.1
Stock Carryout	335.0	389.0	386.8	371.6	332.0	273.4
Farm Prices:						
Price of Soybeans ($/Bu.) *	5.34	5.41	5.61	5.90	6.40	7.17
Price of Soybean Meal ($/Ton) *	227.20	241.16	254.08	272.38	304.11	354.94
Price of Soybean Oil ($/Lb.) *	0.1793	0.1829	0.1922	0.2033	0.2182	0.2301
Real Price of Soybeans ($/Bu., 1989 $)	5.34	5.19	5.19	5.27	5.49	5.92
Farm Program Features:						
CCC Loan Rate ($/Bu.)	4.63	4.60	4.63	4.65	4.67	4.70

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Values.

Addendum:

	1989	1990	1991	1992	1993	1994
Total Ending Stock-to-Total Use Ratio	0.1888	0.1988	0.1974	0.1885	0.1659	0.1334

Appendix Table B5. No Pesticide Annual Soybean Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	60.5	60.3	61.0	61.7	63.5	64.4
Yield Per Planted Acre (Bu.)	31.9	33.4	27.7	25.5	23.3	22.4
Acreage Harvested (Mil. Ac.)	59.1	58.9	59.6	60.3	62.1	62.9
Yield Per Harvested Acre (Bu.)	32.6	34.1	28.3	26.1	23.8	23.0
Supply (Mil. Bu.): *						
Stock Carryin	182.0	335.0	389.0	225.2	115.8	57.3
Current Production	1927.0	2011.3	1688.9	1573.8	1480.0	1445.6
Total Supply	2109.0	2346.3	2078.0	1799.0	1595.8	1502.9
Disappearance (Mil. Bu.): *						
Domestic Use for Crush and Other Uses	1104.0	1230.0	1214.5	1182.7	1146.2	1112.1
Net Exports	670.0	727.3	638.3	500.5	392.3	335.2
Total Disappearance	1774.0	1957.3	1852.8	1683.2	1538.5	1447.3
Stock Carryout	335.0	389.0	225.2	115.8	57.3	55.6
Farm Prices:						
Price of Soybeans ($/Bu.) *	5.34	5.41	7.00	9.53	13.80	17.61
Price of Soybean Meal ($/Ton) *	227.20	241.16	312.00	418.30	570.53	693.93
Price of Soybean Oil ($/Lb.) *	0.1793	0.1829	0.2038	0.2300	0.3050	0.3597
Real Price of Soybeans ($/Bu.; 1989 $)	5.34	5.19	6.45	8.41	11.40	14.11
Farm Program Features:						
CCC Loan Rate ($/Bu.)	4.63	4.60	4.63	4.65	4.67	4.70

NOTES:
- * 19XX Market Year Coverage Begins on Sept. 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.1888	0.1988	0.1215	0.0688	0.0373	0.0384

Appendix Table B6. No Chemical Annual Soybean Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	60.5	60.3	61.3	62.2	60.5	69.3
Yield Per Planted Acre (Bu.)	31.9	33.4	27.6	25.4	23.5	22.3
Acreage Harvested (Mil. Ac.)	59.1	58.9	60.0	60.8	59.1	67.8
Yield Per Harvested Acre (Bu.)	32.6	34.1	28.2	26.0	24.1	22.8
Supply (Mil. Bu.): *						
Stock Carryin	182.0	335.0	389.0	214.0	96.1	37.5
Current Production	1927.0	2011.3	1694.9	1579.0	1421.4	1545.1
Total Supply	2109.0	2346.3	2084.0	1793.0	1517.5	1582.6
Disappearance (Mil. Bu.): *						
Domestic Use for Crush and Other Uses	1104.0	1230.0	1238.1	1220.6	1190.9	1192.6
Net Exports	670.0	727.3	631.9	476.3	289.1	316.4
Total Disappearance	1774.0	1957.3	1870.0	1696.9	1480.0	1509.0
Stock Carryout	335.0	389.0	214.0	96.1	37.5	73.6
Farm Prices:						
Price of Soybeans ($/Bu.) *	5.34	5.41	7.17	10.39	20.83	13.01
Price of Soybean Meal ($/Ton) *	227.20	241.16	300.17	399.82	676.28	390.84
Price of Soybean Oil ($/Lb.) *	0.1793	0.1829	0.2073	0.2706	0.4019	0.4330
Real Price of Soybeans ($/Bu.; 1989 $)	5.34	5.19	6.34	8.94	16.86	9.87
Farm Program Features:						
CCC Loan Rate ($/Bu.)	4.63	4.60	4.63	4.65	4.67	4.70

NOTES:
- * 19XX Market Year Coverage Begins on Sept. 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.1888	0.1988	0.1145	0.0567	0.0254	0.0488

Appendix Table B7. Baseline Annual Wheat Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	76.6	77.1	77.5	78.0	75.1	74.3
Yield Per Planted Acre (Bu.)	26.6	31.9	32.1	32.4	32.7	33.0
Acreage Harvested (Mil. Ac.)	62.1	65.0	65.4	65.7	63.3	62.7
Yield Per Harvested Acre (Bu.)	32.8	37.8	38.1	38.4	38.8	39.2
Supply (Mil. Bu.): *						
Stock Carryin	702.0	443.0	553.6	646.1	718.2	723.9
Current Production	2036.0	2456.8	2487.7	2523.9	2458.3	2454.6
Total Supply	2738.0	2899.8	3041.3	3170.0	3176.5	3178.5
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	165.0	221.5	237.2	248.3	224.7	215.4
Domestic Use for Food and Other Uses	850.0	842.0	856.7	869.2	896.1	885.4
Net Exports	1280.0	1282.7	1301.3	1334.3	1331.8	1372.0
Total Disappearance	2295.0	2346.2	2395.3	2451.8	2452.6	2472.9
Stock Carryout	443.0	553.6	646.1	718.2	723.9	705.6
Farm Prices:						
Price of Wheat ($/Bu.) *	3.94	3.22	3.24	3.29	3.50	3.78
Real Price of Wheat ($/Bu.; 1989 $)	3.94	3.09	3.00	2.94	3.06	3.12
Farm Program Features:						
CCC Loan Rate ($/Bu.)	2.11	1.99	1.93	2.04	2.00	2.01
Target Price ($/Bu.)	4.10	4.00	4.12	4.13	4.15	4.18
Program Yield (Bu.)	34.00	34.00	34.00	34.00	34.00	34.00
ARP Set-aside Rate (%)	10.00	5.00	5.00	5.00	10.00	10.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on June 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.1930	0.2360	0.2697	0.2929	0.2952	0.2853

Appendix Table B8. No Pesticide Annual Wheat Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	76.6	77.1	85.1	85.5	85.2	86.2
Yield Per Planted Acre (Bu.)	26.6	31.9	28.6	27.9	26.8	26.4
Acreage Harvested (Mil. Ac.)	62.1	65.0	71.7	72.1	71.8	72.7
Yield Per Harvested Acre (Bu.)	32.8	37.8	34.0	33.1	31.8	31.4
Supply (Mil. Bu.): *						
Stock Carryin	702.0	443.0	553.6	620.8	636.4	579.7
Current Production	2036.0	2456.8	2436.6	2384.1	2282.7	2280.3
Total Supply	2738.0	2899.8	2990.2	3004.9	2919.1	2860.0
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	165.0	221.5	223.0	227.7	247.2	202.2
Domestic Use for Food and Other Uses	850.0	842.0	864.5	874.3	881.4	890.9
Net Exports	1280.0	1282.7	1281.8	1266.4	1210.8	1192.7
Total Disappearance	2295.0	2346.2	2369.4	2368.5	2339.4	2285.7
Stock Carryout	443.0	553.6	620.8	636.4	579.7	574.3
Farm Prices:						
Price of Wheat ($/Bu.) *	3.94	3.22	3.36	3.60	4.11	4.14
Real Price of Wheat ($/Bu.; 1989 $)	3.94	3.09	3.10	3.18	3.46	3.32
Farm Program Features:						
CCC Loan Rate ($/Bu.)	2.11	1.99	1.93	2.04	2.00	2.01
Target Price ($/Bu.)	4.10	4.00	4.12	4.13	4.15	4.18
Program Yield (Bu.)	34.00	34.00	34.00	34.00	34.00	34.00
ARP Set-aside Rate (%)	10.00	5.00	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on June 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.1930	0.2360	0.2620	0.2687	0.2478	0.2512

Appendix Table B9. No Chemical Annual Wheat Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	76.6	77.1	81.8	80.5	81.2	79.5
Yield Per Planted Acre (Bu.)	26.6	31.9	26.7	25.1	23.7	23.1
Acreage Harvested (Mil. Ac.)	62.1	69.0	69.9	67.9	68.4	67.0
Yield Per Harvested Acre (Bu.)	32.8	37.8	31.6	29.6	28.1	27.4
Supply (Mil. Bu.): *						
Stock Carryin	702.0	443.0	553.6	514.8	423.3	406.0
Current Production	2036.0	2456.8	2181.0	2020.5	1922.7	1836.1
Total Supply	2738.0	2899.8	2734.6	2535.3	2346.0	2242.1
Disappearance (Mil. Bu.): *						
Domestic Use for Feed	160.0	221.5	167.5	196.2	147.5	133.3
Domestic Use for Food and Other Uses	848.0	842.0	857.7	862.0	867.4	866.5
Net Exports	1288.0	1282.7	1194.6	1053.8	925.1	832.8
Total Disappearance	2295.0	2346.2	2219.8	2112.0	1940.0	1832.6
Stock Carryout	443.0	553.6	514.8	423.3	406.0	409.5
Farm Prices:						
Price of Wheat ($/Bu.) *	3.94	3.22	3.95	4.72	3.17	3.76
Real Price of Wheat ($/Bu., 1989 $)	3.94	3.09	3.61	4.09	4.30	4.40
Farm Program Features:						
CCC Loan Rate ($/Bu.)	2.11	1.99	1.93	2.04	2.08	2.01
Target Price ($/Bu.)	4.10	4.00	4.12	4.13	4.15	4.18
Program Yield (Bu.)	34.00	34.00	34.00	34.00	34.00	34.00
ARP Set-aside Rate (%)	10.00	5.00	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on June 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.1930	0.2360	0.2319	0.2004	0.2093	0.2235

Appendix Table B10. Baseline Annual Cotton Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	10.6	12.0	11.7	11.6	11.5	11.5
Yield Per Planted Acre (Lb.)	554.3	623.1	656.9	682.5	657.5	644.1
Acreage Harvested (Mil. Ac.)	9.5	11.3	11.0	10.8	10.8	10.8
Yield Per Harvested Acre (Lb.)	618.4	662.9	667.0	675.8	678.3	685.3
Supply (Thou. Bales): *						
Stock Carryin	7090.0	3880.0	4643.4	4763.2	4727.9	4659.3
Current Production	12240.0	15549.1	15297.8	15262.4	15240.3	15414.6
Total Supply	19330.0	19429.1	19941.2	20025.6	19968.2	20073.9
Disappearance (Thou. Bales): *						
Domestic Mill Use	8100.0	8049.2	8215.8	8309.7	8332.2	8307.2
Net Exports	7350.0	6736.5	6962.1	6987.9	6976.7	7087.7
Total Disappearance	15450.0	14785.7	15178.0	15297.7	15308.9	15395.0
Stock Carryout	3880.0	4643.4	4763.2	4727.9	4659.3	4678.9
Farm Prices:						
Price of Cotton ($/Lb.)	0.6463	0.6046	0.6365	0.6561	0.6681	0.7135
Price of Cottonseed ($/Ton)	74.33	70.03	73.87	80.67	87.33	93.78
Price of Cottonseed Meal	207.46	232.50	234.69	276.90	305.64	342.17
Price of Cottonseed Oil ($/Lb.)	0.2015	0.2077	0.2198	0.2336	0.2362	0.2708
Real Price of Cotton ($/Lb., 1989 $)	0.6463	0.5803	0.5796	0.5817	0.5905	0.5891
Farm Program Features:						
Loan Rate ($/Lb.)	0.5110	0.5115	0.5149	0.5168	0.5184	0.5220
Target Price ($/Lb.)	0.7301	0.7458	0.7388	0.7535	0.7559	0.7610
Program Yield (Lb.)	590.00	590.00	590.00	590.00	590.00	590.00
ARP Set-aside Rate (%)	25.00	12.50	15.00	15.00	15.00	15.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on Aug. 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2511	0.3140	0.3138	0.3091	0.3044	0.3039

Appendix Table B11. No Pesticide Annual Cotton Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	10.6	12.0	13.3	13.1	13.9	13.8
Yield Per Planted Acre (Lb.)	554.3	623.1	496.5	489.6	415.1	397.2
Acreage Harvested (Mil. Ac.)	9.5	11.3	12.5	12.3	12.1	12.2
Yield Per Harvested Acre (Lb.)	618.4	662.9	531.7	484.7	441.6	423.5
Supply (Thou. Bales): *						
Stock Carryin	7090.0	3880.0	4643.4	4170.7	3383.8	2784.0
Current Production	12240.0	15549.1	13862.7	12462.8	11176.7	10776.4
Total Supply	19330.0	19429.1	18506.1	16633.5	14560.5	13560.4
Disappearance (Thou. Bales): *						
Domestic Mill Use	8100.0	8049.2	8213.8	8188.9	7954.4	7324.4
Net Exports	7350.0	6736.5	6121.6	5060.8	3822.1	3602.5
Total Disappearance	15450.0	14785.7	14335.4	13249.7	11776.5	10926.9
Stock Carryout	3880.0	4643.4	4170.7	3383.8	2784.0	2633.5
Farm Prices:						
Price of Cotton ($/Lb.)	0.6463	0.6046	0.6668	0.7801	0.9270	1.0339
Price of Cottonseed ($/Ton)	74.33	70.03	104.26	161.32	277.16	397.98
Price of Cottonseed Meal ($/Ton)	207.46	232.50	304.80	397.42	531.50	621.87
Price of Cottonseed Oil ($/Lb.)	0.2015	0.2077	0.2224	0.2479	0.3083	0.3510
Real Price of Cotton ($/Lb., 1989 $)	0.6463	0.5803	0.6144	0.6707	0.7704	0.8284
Farm Program Features:						
Loan Rate ($/Lb.)	0.5110	0.5115	0.5149	0.5168	0.5184	0.5220
Target Price ($/Lb.)	0.7301	0.7458	0.7388	0.7535	0.7559	0.7610
Program Yield (Lb.)	590.00	590.00	590.00	590.00	590.00	590.00
ARP Set-aside Rate (%)	25.00	12.50	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on Aug. 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2511	0.3140	0.2909	0.2554	0.2364	0.2410

Appendix Table B12. No Chemical Annual Cotton Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	10.6	12.0	13.9	13.6	13.7	14.0
Yield Per Planted Acre (Lb.)	554.3	623.1	405.6	363.7	283.3	248.5
Acreage Harvested (Mil. Ac.)	9.5	11.3	12.1	11.8	11.9	13.2
Yield Per Harvested Acre (Lb.)	618.4	662.9	482.8	373.2	301.4	264.4
Supply (Thou. Bales): *						
Stock Carryin	7090.0	3880.0	4643.4	3201.2	2779.7	2420.3
Current Production	12240.0	15549.1	11453.5	9233.2	7480.9	7263.6
Total Supply	19330.0	19429.1	16096.9	12434.4	10260.6	9683.9
Disappearance (Thou. Bales): *						
Domestic Mill Use	8100.0	8049.2	8215.8	7942.1	6915.1	5909.8
Net Exports	7350.0	6736.5	4679.9	1732.6	933.2	1705.6
Total Disappearance	15450.0	14785.7	12895.7	9674.7	7848.4	7615.4
Stock Carryout	3880.0	4643.4	3201.2	2779.7	2420.3	2068.4
Farm Prices:						
Price of Cotton ($/Lb.)	0.6463	0.6046	0.7599	1.2048	1.7794	1.4865
Price of Cottonseed ($/Ton)	74.33	70.03	131.12	237.98	873.05	413.82
Price of Cottonseed Meal ($/Ton)	207.46	232.50	334.83	480.15	806.84	481.00
Price of Cottonseed Oil ($/Lb.)	0.2015	0.2077	0.2483	0.3344	0.4509	0.3736
Real Price of Cotton ($/Lb., 1989 $)	0.6463	0.5803	0.6933	1.1057	1.4309	1.1281
Farm Program Features:						
Loan Rate ($/Lb.)	0.5110	0.5115	0.5149	0.5168	0.5184	0.5220
Target Price ($/Lb.)	0.7301	0.7458	0.7388	0.7535	0.7559	0.7610
Program Yield (Lb.)	590.00	590.00	590.00	590.00	590.00	590.00
ARP Set-aside Rate (%)	25.00	12.50	0.00	0.00	0.00	0.00
PLD Diversion Rate (%)	0.00	0.00	0.00	0.00	0.00	0.00

NOTES:
- * 19XX Market Year Coverage Begins on Aug. 1, 19XX.
- ** Calendar Year Values.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2511	0.3140	0.2482	0.2873	0.3084	0.2716

Appendix Table B13. Baseline Annual Feed Grain Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	106.9	114.6	112.0	113.2	112.3	112.2
Acreage Harvested (Mil. Ac.)	98.0	104.9	103.4	105.6	103.8	102.7
Supply (Mil. Metric Tons): *						
Stock Carryin	68.5	49.2	63.8	72.7	78.8	79.8
Current Production	222.1	247.1	244.3	245.4	244.0	243.5
Total Supply	290.7	296.2	308.2	318.1	322.8	323.3
Disappearance (Mil. Metric Tons): *						
Domestic Use for Feed	133.1	139.2	141.5	143.6	144.6	144.5
Domestic Use for Food and Other Uses	38.8	31.3	33.5	35.1	36.3	37.3
Net Exports	65.0	61.8	60.4	60.6	62.1	65.5
Total Disappearance	236.9	232.4	235.5	239.2	242.9	247.2
Stock Carryout	49.2	63.8	72.7	78.8	79.8	76.1
Farm Prices:						
Nominal Price Index (1988=100) **	90.8	91.7	92.8	94.3	98.7	105.2
Real Price Index (1989 $) **	90.8	88.0	85.9	84.2	84.7	86.8

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Value.
*** Includes Corn, Sorghum, Barley and Oats.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2075	0.2747	0.3087	0.3295	0.3286	0.3079

Appendix Table B14. No Pesticide Annual Feed Grain Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	106.9	114.6	122.4	122.2	122.0	127.4
Acreage Harvested (Mil. Ac.)	98.0	104.9	112.0	111.8	111.7	116.6
Supply (Mil. Metric Tons): *						
Stock Carryin	68.5	49.2	63.8	53.5	32.9	23.4
Current Production	222.1	247.1	222.6	206.0	194.9	221.9
Total Supply	290.7	296.2	286.4	259.5	227.8	245.3
Disappearance (Mil. Metric Tons): *						
Domestic Use for Feed	133.1	139.2	140.6	137.4	124.1	132.4
Domestic Use for Food and Other Uses	38.8	31.3	32.9	32.9	31.0	33.4
Net Exports	65.0	61.8	59.5	56.2	49.3	50.8
Total Disappearance	236.9	232.4	232.9	226.6	204.4	216.7
Stock Carryout	49.2	63.8	53.5	32.9	23.4	28.6
Farm Prices:						
Nominal Price Index (1988=100) **	90.8	91.7	96.4	113.2	178.1	132.3
Real Price Index (1989 $) **	90.8	88.0	88.8	99.9	149.5	106.0

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Value.
*** Includes Corn, Sorghum, Barley and Oats.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2075	0.2747	0.2298	0.1452	0.1147	0.1321

Appendix Table B15. No Chemical Annual Feed Grain Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Production Data:						
Acreage Planted (Mil. Ac.)	106.9	114.6	119.2	118.0	125.7	119.3
Acreage Harvested (Mil. Ac.)	98.0	104.9	109.1	108.0	115.0	109.2
Supply (Mil. Metric Tons): *						
Stock Carryin	68.5	49.2	63.8	34.3	19.3	19.2
Current Production	222.1	247.1	192.2	171.6	187.0	162.9
Total Supply	290.7	296.2	256.0	205.9	206.4	182.2
Disappearance (Mil. Metric Tons): *						
Domestic Use for Feed	133.1	139.2	134.2	114.6	118.3	103.6
Domestic Use for Food and Other Uses	38.8	31.3	31.5	28.1	28.9	26.7
Net Exports	65.0	61.8	56.0	43.9	39.9	35.7
Total Disappearance	236.9	232.4	221.7	186.5	187.1	166.0
Stock Carryout	49.2	63.8	34.3	19.3	19.2	16.2
Farm Prices:						
Nominal Price Index (1988=100) **	90.8	91.7	115.8	236.7	201.2	293.4
Real Price Index (1989 $) **	90.8	88.0	106.6	203.7	162.7	222.7

NOTES:
* 19XX Market Year Coverage Begins on Sept. 1, 19XX.
** Calendar Year Value.
*** Includes Corn, Sorghum, Barley and Oats.

Addendum:						
Total Ending Stock-to-Total Use Ratio	0.2075	0.2747	0.1547	0.1037	0.1022	0.0975

APPENDIX C

Appendix Table C1. Baseline Annual Cattle Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Stock of Beef Cows (1000 Head)*:						
Beginning Stock of Beef Cows	33669.0	33705.0	34459.8	35747.9	36959.3	37738.5
Net Replacements to Herds	36.0	754.8	1288.1	1211.4	779.2	417.1
Ending Stock of Beef Cows	33705.0	34459.8	35747.9	36959.3	37738.5	38155.6
Stock of Dairy Cows (1000 Head)*:						
Beginning Stock of Dairy Cows	10217.0	10149.0	10063.5	9976.7	9891.3	9824.5
Net Replacements to Herds	-68.0	-85.5	-86.9	-85.3	-66.8	-69.8
Ending Stock of Dairy Cows	10149.0	10063.5	9976.7	9891.3	9824.5	9754.7
Calf Crop (1000 Head)	40588.0	41959.5	42768.7	43488.9	43863.1	44042.7
Slaughter/Production:						
Calf Slaughter (1000 Head)	2099.5	2106.9	2151.2	2215.6	2264.7	2291.1
Cow Slaughter (1000 Head)	6146.1	5537.0	6102.5	6525.3	6925.6	7134.9
Steer and Heifer Slaughter (1000 Head)	26221.8	26679.1	27294.4	28182.6	28434.0	28548.4
Calf Dressed Weight (Lb.)	158.0	158.0	158.0	158.0	158.0	158.0
Cow Dressed Weight (Lb.)	539.0	541.2	543.3	545.5	547.7	549.8
Steer and Heifer Dressed Weight (Lb.)	713.2	716.1	718.9	721.8	724.7	727.6
Commercial Beef Production (Mil. Lb.)	22974.0	22817.6	23656.3	24623.5	25116.7	25422.2
Beef Imports (Mil. Lb.)	2175.0	2175.0	2175.0	2175.0	2175.0	2175.0
Consumption:						
Per Capita Beef Consumption (Lb.)	68.41	67.30	68.96	70.94	71.57	71.69
Market Prices:						
Price of Steers and Heifers ($/Cwt)	72.40	72.97	74.89	75.79	77.77	80.27
Price of Cows ($/Cwt)	47.72	46.99	48.60	47.90	48.57	49.91
Price of Calves ($/Cwt)	86.52	88.71	89.87	90.95	93.32	96.33
Price of Veal Calves ($/Cwt)	94.64	111.79	114.21	116.78	120.47	124.51

NOTE:
* Includes Heifers That Have Calved
** Retail Weight Basis

Appendix Table C2. No Pesticide Annual Cattle Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Stock of Beef Cows (1000 Head)*:						
Beginning Stock of Beef Cows	33669.0	33705.0	34459.8	35747.9	36959.3	37685.2
Net Replacements to Herds	36.0	754.8	1288.1	1211.4	725.9	260.3
Ending Stock of Beef Cows	33705.0	34459.8	35747.9	36959.3	37685.2	37945.5
Stock of Dairy Cows (1000 Head)*:						
Beginning Stock of Dairy Cows	10217.0	10149.0	10063.5	9976.7	9891.3	9824.5
Net Replacements to Herds	-68.0	-85.5	-86.9	-85.3	-66.8	-69.8
Ending Stock of Dairy Cows	10149.0	10063.5	9976.7	9891.3	9824.5	9754.7
Calf Crop (1000 Head)	40588.0	41959.5	42871.2	43494.3	43598.4	43630.5
Slaughter/Production:						
Calf Slaughter (1000 Head)	2099.5	2106.9	2148.5	2285.0	2230.4	2246.1
Cow Slaughter (1000 Head)	6146.1	5537.0	6113.0	6658.4	7270.2	7851.3
Steer and Heifer Slaughter (1000 Head)	26221.8	26679.1	27242.5	27967.0	27760.2	27480.9
Calf Dressed Weight (Lb.)	158.0	158.0	158.0	158.0	158.0	158.0
Cow Dressed Weight (Lb.)	539.0	541.2	543.3	545.5	547.7	549.8
Steer and Heifer Dressed Weight (Lb.)	713.2	716.1	718.9	721.8	724.7	727.6
Commercial Beef Production (Mil. Lb.)	22974.0	22817.6	23624.7	24540.6	24830.9	25039.4
Beef Imports (Mil. Lb.)	2175.0	2175.0	2175.0	2175.0	2175.0	2175.0
Consumption:						
Per Capita Beef Consumption (Lb.)	68.41	67.30	68.87	70.71	70.79	70.66
Market Prices:						
Price of Steers and Heifers ($/Cwt)	72.40	72.97	75.07	76.47	79.62	82.87
Price of Cows ($/Cwt)	47.72	46.99	48.83	48.59	50.51	52.02
Price of Calves ($/Cwt)	86.52	88.71	90.08	91.77	95.54	99.45
Price of Veal Calves ($/Cwt)	94.64	111.79	114.40	117.58	122.49	127.36

NOTE:
* Includes Heifers That Have Calved
** Retail Weight Basis

Appendix Table C3. No Chemical Annual Cattle Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Stock of Beef Cows (1000 Head)*:						
Beginning Stock of Beef Cows	33669.0	33705.0	34459.8	35747.9	36959.3	37644.2
Net Replacements to Herds	36.0	754.8	1288.1	1211.4	684.9	32.1
Ending Stock of Beef Cows	33705.0	34459.8	35747.9	36959.3	37644.2	37676.3
Stock of Dairy Cows (1000 Head)*:						
Beginning Stock of Dairy Cows	10217.0	10149.0	10063.5	9976.7	9891.3	9824.5
Net Replacements to Herds	-68.0	-85.5	-86.9	-85.3	-66.8	-69.8
Ending Stock of Dairy Cows	10149.0	10063.5	9976.7	9891.3	9824.5	9754.7
Calf Crop (1000 Head)	40588.0	41959.5	42747.3	43822.1	43160.0	42747.5
Slaughter/Production:						
Calf Slaughter (1000 Head)	2099.5	2106.9	2127.3	2151.7	2181.6	2168.2
Cow Slaughter (1000 Head)	6146.1	5537.0	6121.0	6881.1	7815.7	8284.5
Steer and Heifer Slaughter (1000 Head)	26221.8	26679.1	27133.9	27339.7	26798.0	25693.8
Calf Dressed Weight (Lb.)	158.0	158.0	158.0	158.0	158.0	158.0
Cow Dressed Weight (Lb.)	539.0	541.2	543.3	545.5	547.7	549.8
Steer and Heifer Dressed Weight (Lb.)	713.2	716.1	718.9	721.8	724.7	727.6
Commercial Beef Production (Mil. Lb.)	22974.0	22817.6	23551.0	24165.6	24425.7	23977.2
Beef Imports (Mil. Lb.)	2175.0	2175.0	2175.0	2175.0	2175.0	2175.0
Consumption:						
Per Capita Beef Consumption (Lb.)	68.41	67.30	68.66	69.67	69.69	67.79
Market Prices:						
Price of Steers and Heifers ($/Cwt)	72.40	72.97	75.63	78.89	82.23	88.22
Price of Cows ($/Cwt)	47.72	46.99	49.51	51.48	52.42	57.23
Price of Calves ($/Cwt)	86.52	88.71	90.77	94.68	98.66	105.87
Price of Veal Calves ($/Cwt)	94.64	111.79	114.98	119.96	125.58	133.91

NOTE:
* Includes Heifers That Have Calved
** Retail Weight Basis

Appendix Table C4. Baseline Annual Hog Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Hog Breeding Activity (1000 Head)*:						
Sows Bred - Spring	7350.0	7392.0	7344.9	7482.4	7458.7	7457.4
Sows Farrow - Spring	6014.0	6072.6	6148.4	6178.4	6288.1	6233.1
Pig Crop - Spring	47832.0	46151.7	46727.5	48036.0	47181.9	47371.5
Sows Bred - Fall	7485.6	7498.0	7534.7	7778.0	7601.3	7608.6
Sows Farrow - Fall	5777.0	6061.4	6082.8	6070.0	6109.5	6115.0
Pig Crop - Fall	44832.0	46066.9	45773.4	46131.7	46432.5	46474.3
Slaughter/Production:						
Hog Slaughter (1000 Head)	88093.3	86510.1	85501.9	85304.5	85804.3	86358.5
Hog Dressed Weight (Lb.)	179.0	179.7	180.4	181.2	181.9	182.6
Processed Pork Production (Mil. Lb.)	15758.0	15545.9	15424.5	15457.2	15622.4	15780.1
Consumption:						
Per Capita Pork Consumption (Lb.) **	62.9	64.6	63.5	63.0	63.0	63.0
Market Prices:						
Farm Price of Hogs ($/Cwt)	43.87	44.78	40.50	42.41	44.88	46.74

NOTE:
* Includes Hogs and Pigs Kept for Breeding Purposes.
** Retail Weight Basis.

Appendix Table C5. No Pesticide Annual Hog Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Hog Breeding Activity (1000 Head)*:						
Sows Bred - Spring	7330.0	7302.0	7344.9	7312.1	7115.3	6479.2
Sows Farrow - Spring	6014.0	6072.6	6148.4	6178.4	6461.5	6859.8
Pig Crop - Spring	47032.0	46151.7	46727.5	46956.8	46627.1	46054.2
Sows Bred - Fall	7485.6	7498.0	7534.7	7514.8	7309.9	6909.0
Sows Farrow - Fall	5777.0	6061.4	6022.8	5995.9	5834.5	5313.0
Pig Crop - Fall	44852.0	46066.9	45773.4	45508.8	44342.6	40378.6
Slaughter/Production:						
Hog Slaughter (1000 Head)	88695.3	86516.1	85581.9	85271.2	84878.1	82720.8
Hog Dressed Weight (Lb.)	179.0	179.7	180.4	181.2	181.9	182.6
Processed Pork Production (Mil. Lb.)	15758.0	15545.9	15424.5	15451.1	15439.3	15104.8
Consumption:						
Per Capita Pork Consumption (Lb.) **	62.9	64.6	63.5	63.0	62.3	60.4
Market Prices:						
Farm Price of Hogs ($/Cwt)	43.87	44.78	40.55	42.67	44.80	47.33

NOTE:
- * Includes Hogs and Pigs Kept for Breeding Purposes.
- ** Retail Weight Basis.

Appendix Table C6. No Chemical Annual Hog Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Hog Breeding Activity (1000 Head)*:						
Sows Bred - Spring	7330.0	7302.0	7344.9	7179.3	6269.1	5548.5
Sows Farrow - Spring	6014.0	6072.6	6148.4	6178.4	6002.8	5622.4
Pig Crop - Spring	47032.0	46151.7	46727.5	46956.0	46305.6	42730.2
Sows Bred - Fall	7485.6	7498.0	7534.7	7430.3	6836.6	6482.4
Sows Farrow - Fall	5777.0	6061.4	6022.8	5887.0	5148.7	4549.8
Pig Crop - Fall	44852.0	46066.9	45773.4	44741.6	39869.0	34578.1
Slaughter/Production:						
Hog Slaughter (1000 Head)	88695.3	86510.1	85581.9	85222.4	83260.2	74107.4
Hog Dressed Weight (Lb.)	179.0	179.7	180.4	181.2	181.9	182.6
Processed Pork Production (Mil. Lb.)	15758.0	15545.9	15424.5	15442.3	15146.7	13532.0
Consumption:						
Per Capita Pork Consumption (Lb.) **	62.9	64.6	63.5	63.0	61.2	54.4
Market Prices:						
Farm Price of Hogs ($/Cwt)	43.87	44.78	40.65	43.01	45.92	50.86

NOTE:
- * Includes Hogs and Pigs Kept for Breeding Purposes.
- ** Retail Weight Basis.

Appendix Table C7. Baseline Annual Poultry, Milk and Sheep Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Sheep Statistics:						
Ewes One Year and Older (1000 Head)	7187.1	8505.0	8708.2	8830.3	8504.7	8045.1
Lamb Crop (1000 Head)	7730.0	8985.9	9256.1	9319.8	8983.6	8514.9
Lamb Slaughter (1000 Head)	5295.0	5588.2	6627.8	6854.7	6988.3	6627.5
Lamb Dressed Weight (Lb.)	64.7	64.9	65.2	65.4	65.7	66.0
Lamb Production (Mil. Lb.)	341.0	362.3	432.0	448.6	453.9	437.1
Per Capita Lamb Consumption (Lb.) *	1.1	1.1	1.3	1.3	1.3	1.3
Price of Lamb ($/Cwt)	63.87	57.95	50.85	50.99	51.76	55.13
Poultry Statistics:						
Broiler Production (Mil. Lb.)	24733.1	25963.3	26512.3	26781.4	26934.2	26980.7
Per Capita Broiler Consumption (Lb.) *	67.6	70.7	71.5	71.5	71.2	70.7
Price of Broilers (Cents/Lb.)	35.81	34.75	33.05	32.97	33.72	35.15
Turkey Production (Mil. Lb.)	5264.6	6088.1	6237.2	6342.2	6302.4	6408.9
Per Capita Turkey Consumption (Lb.) *	16.7	16.7	17.2	17.3	17.3	17.2
Price of Turkey (Cents/Lb.)	40.09	51.73	47.83	47.06	47.45	49.15
Egg Production (Mil. Doz)	6004.3	5847.6	5733.6	5718.5	5779.6	5880.6
Per Capita Egg Consumption (Doz)	21.2	20.2	19.5	19.2	19.3	19.5
Price of Eggs (Cents/Doz)	69.42	71.75	73.38	80.72	81.79	79.91
Milk Statistics:						
Milk Production (Mil. Lb.)	145342.0	146998.1	147719.3	148763.5	149996.5	151151.7
Milk Production Per Cow (Lb.)	14320.8	14607.8	14806.5	15039.8	15267.6	15491.5
Per Capita Milk Consumption (Lb.)	571.97	572.89	570.06	568.49	567.62	566.42
Price of Milk ($/Cwt)	13.45	13.24	13.79	14.33	14.95	15.61
Milk Support Price ($/Cwt)	10.80	10.44	10.47	10.48	10.51	10.54

NOTE:
* Retail Weight Basis.

Appendix Table C8. No Pesticide Annual Poultry, Milk and Sheep Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Sheep Statistics:						
Ewes One Year and Older (1000 Head)	7187.1	8605.0	8708.2	8830.3	8465.3	7873.9
Lamb Crop (1000 Head)	7730.0	8985.9	9256.1	9319.8	8845.2	8328.0
Lamb Slaughter (1000 Head)	5295.0	5588.2	6627.8	6854.7	6988.3	6593.5
Lamb Dressed Weight (Lb.)	64.7	64.9	65.2	65.4	65.7	66.0
Lamb Production (Mil. Lb.)	341.0	362.3	432.0	448.6	453.9	434.9
Per Capita Lamb Consumption (Lb.) *	1.1	1.1	1.3	1.3	1.3	1.3
Price of Lamb ($/Cwt)	63.87	57.95	50.68	50.84	52.01	56.65
Poultry Statistics:						
Broiler Production (Mil. Lb.)	24733.1	25963.3	26512.3	26656.0	26531.2	26067.0
Per Capita Broiler Consumption (Lb.) *	67.6	70.7	71.5	71.2	70.1	68.2
Price of Broilers (Cents/Lb.)	35.81	34.75	32.87	33.44	36.10	42.75
Turkey Production (Mil. Lb.)	5264.6	6088.1	6237.2	6309.9	6292.0	6179.7
Per Capita Turkey Consumption (Lb.) *	16.7	16.7	17.2	17.2	17.0	16.3
Price of Turkey (Cents/Lb.)	40.09	51.73	47.88	48.39	52.46	58.87
Egg Production (Mil. Doz)	6004.3	5847.6	5733.6	5699.8	5712.0	5705.2
Per Capita Egg Consumption (Doz)	21.2	20.2	19.5	19.2	19.1	18.9
Price of Eggs (Cents/Doz)	69.42	71.75	73.22	81.82	86.82	93.80
Milk Statistics:						
Milk Production (Mil. Lb.)	145342.0	146998.1	147719.3	148512.8	149320.1	149305.2
Milk Production Per Cow (Lb.)	14320.8	14607.0	14806.5	15014.5	15198.7	15326.5
Per Capita Milk Consumption (Lb.)	571.97	572.89	570.06	567.51	565.01	560.12
Price of Milk ($/Cwt)	13.45	13.24	13.83	14.46	15.21	16.10
Milk Support Price ($/Cwt)	10.80	10.44	10.46	10.53	10.63	10.76

NOTE:
* Retail Weight Basis.

Appendix Table C9. No Chemical Animal Poultry, Milk and Sheep Statistics

ITEMS	1989	1990	1991	1992	1993	1994
Sheep Statistics						
Ewes One Year and Older (1000 Head)	7187.1	8305.0	8768.2	8830.3	8447.9	7759.3
Lamb Crop (1000 Head)	7739.0	8985.9	9256.1	9319.8	8927.3	8220.4
Lamb Slaughter (1000 Head)	5295.0	5580.2	6627.8	6854.7	6988.3	6578.5
Lamb Dressed Weight (Lb.)	64.7	64.9	65.2	65.4	65.7	66.0
Lamb Production (Mil. Lb.)	341.0	362.3	432.0	448.6	453.9	433.9
Per Capita Lamb Consumption (Lb.) *	1.1	1.1	1.3	1.3	1.3	1.3
Price of Lamb ($/Cwt)	63.87	57.95	58.86	51.46	53.76	60.61
Poultry Statistics						
Broiler Production (Mil. Lb.)	24733.1	25963.3	26512.3	26588.0	26100.1	25429.3
Per Capita Broiler Consumption (Lb.) *	67.6	70.7	71.5	71.0	69.0	66.5
Price of Broilers (Cents/Lb.)	35.81	34.75	33.80	34.38	41.09	53.76
Turkey Production (Mil. Lb.)	5264.6	6008.1	6237.2	6295.9	6198.5	6000.7
Per Capita Turkey Consumption (Lb.) *	16.7	16.7	17.2	17.2	16.8	16.1
Price of Turkey (Cents/Lb.)	40.09	51.73	48.65	51.90	57.39	74.31
Egg Production (Mil. Doz)	6004.3	5847.6	5735.6	5685.7	5626.8	5550.8
Per Capita Egg Consumption (Doz)	21.2	20.2	19.5	19.1	18.8	18.3
Price of Eggs (Cents/Doz)	69.42	71.75	73.46	83.75	95.93	113.18
Milk Statistics						
Milk Production (Mil. Lb.)	145342.0	146998.1	147719.3	148253.5	148047.4	148392.1
Milk Production Per Cow (Lb.)	14320.8	14607.0	14806.5	14988.2	15069.2	15212.4
Per Capita Milk Consumption (Lb.)	571.97	572.89	570.06	566.50	560.10	555.87
Price of Milk ($/Cwt)	13.45	13.24	13.86	14.63	15.68	16.78
Milk Support Price ($/Cwt)	10.80	10.44	10.51	10.65	10.88	11.20

NOTE:
* Retail Weight Basis

APPENDIX D

Appendix Table D1. Baseline Corn Belt Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	34.5	35.9	35.7	35.9	35.7	35.6
Sorghum	0.8	0.9	1.0	1.0	1.0	1.1
Oats	1.5	1.4	1.4	1.4	1.3	1.3
Wheat	4.8	4.9	4.8	4.8	4.7	4.7
Soybeans	32.4	31.6	30.6	30.6	30.7	31.0
Cotton	0.2	0.1	0.1	0.1	0.1	0.1
All hay	10.4	9.3	8.6	8.3	8.1	8.0
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	3.4	3.5	5.1	5.1	5.3	5.3
Conservation Reserve Acres	3.6	4.7	4.7	4.7	4.7	4.7
Total	91.6	92.3	91.9	91.9	91.8	91.8
PRODUCTION:						
Corn (Million Bushels)	4220.3	4412.3	4424.5	4488.5	4505.8	4518.5
Sorghum (Million Bushels)	69.1	78.4	83.3	86.6	87.1	86.4
Oats (Million Bushels)	42.2	28.2	30.4	29.5	29.5	29.5
Wheat (Million Bushels)	192.8	195.3	192.7	192.7	190.3	186.8
Soybeans (Million Bushels)	1191.1	1170.9	1144.4	1156.3	1169.5	1193.0
Cotton (Million Pounds)	95.3	73.9	55.8	45.8	43.2	45.6
All hay (Million Tons)	28.7	25.9	23.9	23.3	23.0	23.0
YIELD PER ACRE:						
Corn (Bushels)	122.15	123.00	124.04	125.07	126.07	127.06
Sorghum (Bushels)	89.14	86.38	85.59	84.65	83.54	82.26
Oats (Bushels)	28.56	19.96	21.92	21.56	21.87	22.09
Wheat (Bushels)	40.35	40.12	40.18	40.21	40.20	40.16
Soybeans (Bushels)	36.78	37.11	37.44	37.78	38.11	38.44
Cotton (Pounds)	521.65	529.05	536.44	543.84	551.23	558.63
All hay (Tons)	2.75	2.77	2.80	2.82	2.85	2.87
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.30	2.33	2.37	2.49	2.66
Sorghum ($/Bushel)	1.89	1.92	1.95	1.99	2.10	2.26
Oats ($/Bushel)	1.28	1.57	1.60	1.68	1.77	1.85
Wheat ($/Bushel)	3.85	3.25	3.29	3.36	3.62	3.85
Soybeans ($/Bushel)	5.35	5.39	5.60	5.91	6.43	7.24
Cotton ($/Pound)	0.66	0.62	0.65	0.68	0.71	0.74
All hay ($/Ton)	64.12	67.19	73.93	80.16	86.28	90.32
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	19.0	19.1	19.4	20.2	21.7	23.8
Income Above Variable Costs	11.5	11.0	11.2	11.8	12.8	14.3
Income Above Fixed Costs	6.2	5.6	5.7	6.1	6.9	8.2
ARP Payments	2.0	1.9	1.7	1.6	1.3	0.7
Net Farm Income	8.2	7.5	7.5	7.8	8.2	8.9
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	143.38	149.20	156.96	166.41
Sorghum	62.99	67.68	69.81	72.91	76.89	81.60
Oats	37.70	40.49	42.13	44.17	46.70	49.57
Wheat	72.18	77.46	79.65	82.93	87.27	92.53
Soybeans	55.28	59.30	61.13	63.74	67.12	71.17
Cotton	237.65	256.53	266.24	279.25	295.49	314.08
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D3. No Chemical Corn Belt Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	34.5	35.9	37.7	37.6	40.4	38.6
Sorghum	0.8	0.9	1.1	1.1	1.2	1.2
Oats	1.5	1.4	1.5	1.4	1.4	1.4
Wheat	4.8	4.9	5.1	4.9	4.8	3.9
Soybeans	32.4	31.6	32.6	33.1	33.4	37.3
Cotton	0.2	0.1	0.1	0.1	0.0	0.1
All Hay	10.4	9.3	9.1	8.8	9.1	9.2
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	3.4	3.5	0.0	0.0	0.0	0.0
Conservation Reserve Acres	3.6	4.7	4.7	4.7	4.7	4.7
Total	91.6	92.3	91.9	91.8	95.2	96.5
PRODUCTION:						
Corn (Million Bushels)	4220.3	4412.3	3552.5	3145.8	3037.0	2681.1
Sorghum (Million Bushels)	69.1	78.4	73.3	69.8	92.0	86.4
Oats (Million Bushels)	42.2	28.2	26.5	26.3	24.3	25.2
Wheat (Million Bushels)	192.8	195.3	169.8	149.7	141.2	111.1
Soybeans (Million Bushels)	1191.1	1170.9	1020.1	962.7	896.0	961.9
Cotton (Million Pounds)	95.3	73.9	32.4	21.0	10.0	14.8
All Hay (Million Tons)	28.7	25.9	25.5	25.0	26.0	26.6
YIELD PER ACRE:						
Corn (Bushels)	122.15	123.00	94.27	83.68	75.17	69.44
Sorghum (Bushels)	89.14	86.38	69.76	62.72	76.01	71.54
Oats (Bushels)	28.56	19.96	18.08	18.50	17.63	17.89
Wheat (Bushels)	40.35	40.12	33.15	30.36	29.26	28.82
Soybeans (Bushels)	36.78	37.11	31.27	29.05	26.79	25.76
Cotton (Pounds)	521.65	529.05	348.69	277.36	203.96	167.59
All Hay (Tons)	2.75	2.77	2.80	2.82	2.85	2.87
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.30	3.00	6.44	5.45	7.98
Sorghum ($/Bushel)	1.89	1.92	2.2[illegible]	3.56	3.52	4.90
Oats ($/Bushel)	1.28	1.57	1.[illegible]5	2.07	2.43	2.62
Wheat ($/Bushel)	3.85	3.25	3.92	4.66	5.11	5.68
Soybeans ($/Bushel)	5.35	5.39	7.22	10.57	21.18	13.52
Cotton ($/Pound)	0.66	0.62	0.77	1.26	1.73	1.47
All Hay ($/Ton)	64.12	67.19	75.65	97.90	102.66	112.46
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	19.0	19.1	20.8	33.9	39.3	38.5
Income Above Variable Costs	11.5	11.0	13.7	27.0	32.2	30.9
Income Above Fixed Costs	6.2	5.6	8.2	21.2	25.9	24.0
ARP Payments	2.0	1.9	0.1	0.0	0.0	0.0
Net Farm Income	8.2	7.5	8.3	21.2	25.9	24.0
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	109.73	102.34	96.26	98.90
Sorghum	62.99	67.68	75.11	82.71	93.37	105.74
Oats	37.70	40.49	40.04	42.34	46.44	52.63
Wheat	72.18	77.46	71.82	73.40	77.72	86.39
Soybeans	55.28	59.30	54.27	55.11	57.45	62.63
Cotton	237.65	256.53	215.13	209.10	204.64	212.91
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D2. No Pesticide Corn Belt Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	34.5	35.9	37.8	37.6	37.3	38.6
Sorghum	0.8	0.9	1.1	1.1	1.2	1.2
Oats	1.5	1.4	1.5	1.4	1.4	1.4
Wheat	4.8	4.9	5.1	5.0	4.7	4.3
Soybeans	32.4	31.6	32.5	33.0	34.0	35.1
Cotton	0.2	0.1	0.1	0.1	0.0	0.1
All Hay	10.4	9.3	9.1	8.8	8.7	9.0
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	3.4	3.5	0.0	0.0	0.0	0.0
Conservation Reserve Acres	3.6	4.7	4.7	4.7	4.7	4.7
Total	91.6	92.3	91.9	91.7	92.0	94.3
PRODUCTION:						
Corn (Million Bushels)	4220.3	4412.3	3964.1	3683.5	3403.7	3502.6
Sorghum (Million Bushels)	69.1	78.4	81.3	82.1	80.2	83.4
Oats (Million Bushels)	42.2	28.2	29.2	28.8	28.0	28.1
Wheat (Million Bushels)	192.8	195.3	188.5	175.4	159.1	143.5
Soybeans (Million Bushels)	1191.1	1170.9	1015.6	957.6	910.3	903.1
Cotton (Million Pounds)	95.3	73.9	36.2	20.5	13.8	15.0
All Hay (Million Tons)	28.7	25.9	25.5	24.9	24.9	25.7
YIELD PER ACRE:						
Corn (Bushels)	122.15	123.00	104.81	97.93	91.35	90.77
Sorghum (Bushels)	89.14	86.38	77.03	72.80	68.51	68.86
Oats (Bushels)	28.56	19.96	20.06	20.15	19.97	20.19
Wheat (Bushels)	40.35	40.12	36.77	35.42	34.05	33.34
Soybeans (Bushels)	36.78	37.11	31.27	29.05	26.79	25.76
Cotton (Pounds)	521.65	529.05	405.02	357.30	308.14	284.90
All Hay (Tons)	2.75	2.77	2.80	2.82	2.85	2.87
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.30	2.44	2.92	4.80	3.43
Sorghum ($/Bushel)	1.89	1.92	1.86	2.04	2.64	2.66
Oats ($/Bushel)	1.28	1.57	1.71	1.86	2.04	2.18
Wheat ($/Bushel)	3.85	3.25	3.40	3.64	4.13	4.20
Soybeans ($/Bushel)	5.35	5.39	7.01	9.59	13.88	17.85
Cotton ($/Pound)	0.66	0.62	0.68	0.78	0.94	1.04
All Hay ($/Ton)	64.12	67.19	70.05	78.04	90.88	87.90
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	19.0	19.1	19.4	22.7	32.2	31.3
Income Above Variable Costs	11.5	11.0	11.8	15.1	24.5	23.0
Income Above Fixed Costs	6.2	5.6	6.3	9.5	18.5	16.6
ARP Payments	2.0	1.9	1.4	0.2	0.0	0.0
Net Farm Income	8.2	7.5	7.7	9.6	18.5	16.6
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	123.13	120.87	120.40	125.56
Sorghum	62.99	67.68	63.36	64.00	65.55	69.07
Oats	37.70	40.49	46.45	51.00	57.00	63.25
Wheat	72.18	77.46	84.43	90.66	99.29	109.05
Soybeans	55.28	59.30	53.73	53.69	54.61	57.69
Cotton	237.65	256.53	232.30	232.53	235.48	246.25
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D5. No Pesticide Lake States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.3	12.2	11.9	11.6	11.5	11.8
Barley	1.3	1.2	1.1	1.1	1.0	1.0
Oats	3.0	2.9	2.8	2.7	2.7	2.6
Wheat	4.1	4.8	5.3	5.4	5.4	5.3
Soybeans	6.2	5.5	5.1	5.1	5.2	5.4
All Hay	8.6	7.5	6.8	6.5	6.3	6.3
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.0	0.0	0.0	0.0
Conservation Reserve Acres	2.1	2.7	2.7	2.7	2.7	2.7
Total	37.6	35.6	35.7	35.1	34.8	35.3
PRODUCTION:						
Corn (Million Bushels)	1386.8	1375.4	1141.8	1045.7	970.2	1053.6
Barley (Million Bushels)	66.8	60.3	52.2	49.0	46.8	47.0
Oats (Million Bushels)	123.1	78.7	68.2	70.1	70.5	70.2
Wheat (Million Bushels)	180.6	211.4	218.8	219.3	212.3	210.9
Soybeans (Million Bushels)	229.1	206.1	162.5	149.3	141.3	142.6
All Hay (Million Tons)	28.7	25.2	23.3	22.4	22.1	22.5
YIELD PER ACRE:						
Corn (Bushels)	112.89	113.11	96.25	89.77	84.19	89.13
Barley (Bushels)	51.77	51.53	47.53	46.35	45.22	45.03
Oats (Bushels)	40.42	27.54	24.52	25.49	25.81	26.64
Wheat (Bushels)	43.70	44.47	41.22	40.33	39.38	39.61
Soybeans (Bushels)	37.20	37.59	31.72	29.52	27.26	26.24
All Hay (Tons)	3.32	3.36	3.41	3.45	3.50	3.54
MARKET PRICES:						
Corn ($/Bushel)	2.19	2.17	2.30	2.76	4.61	3.26
Barley ($/Bushel)	2.09	2.18	2.42	2.65	3.06	3.37
Oats ($/Bushel)	1.15	1.43	1.56	1.70	1.88	2.01
Wheat ($/Bushel)	4.07	3.40	3.56	3.82	4.34	4.42
Soybeans ($/Bushel)	5.18	5.21	6.82	9.40	13.68	17.65
All Hay ($/Ton)	59.64	62.51	65.19	73.00	85.66	82.37
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	6.9	6.6	6.3	7.0	9.5	9.0
Income Above Variable Costs	3.9	3.5	3.4	4.1	6.5	5.8
Income Above Fixed Costs	1.7	1.1	0.9	1.5	3.7	2.7
ARP Payments	0.7	0.7	0.3	0.1	0.0	0.0
Net Farm Income	2.4	1.8	1.4	1.6	3.7	2.7
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	123.13	120.87	120.40	125.56
Barley	78.68	84.67	89.22	94.97	102.40	110.78
Oats	37.70	40.49	46.45	51.00	57.00	63.25
Wheat	72.18	77.46	84.43	90.66	99.29	109.05
Soybeans	55.28	59.30	53.73	53.69	54.61	57.69
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D4. Baseline Lake States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.3	12.2	11.8	11.8	11.7	11.7
Barley	1.3	1.2	1.1	1.1	1.0	1.0
Oats	3.0	2.9	2.7	2.7	2.6	2.6
Wheat	4.1	4.8	4.9	5.0	4.7	4.5
Soybeans	6.2	5.5	5.1	5.0	5.0	5.0
All hay	8.6	7.5	6.8	6.5	6.4	6.3
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.6	0.6	0.9	0.9
Conservation Reserve Acres	2.1	2.7	2.7	2.7	2.7	2.7
Total	37.6	36.6	35.8	35.3	34.9	34.7
PRODUCTION:						
Corn (Million Bushels)	1386.8	1375.4	1347.7	1349.6	1350.3	1354.4
Barley (Million Bushels)	66.8	60.3	57.0	55.6	55.0	55.3
Oats (Million Bushels)	123.1	78.7	73.2	69.1	69.9	70.7
Wheat (Million Bushels)	180.6	211.4	222.1	229.9	218.5	214.7
Soybeans (Million Bushels)	229.1	206.1	194.3	191.5	192.6	196.7
All hay (Million Tons)	28.7	25.2	23.2	22.4	22.2	22.4
YIELD PER ACRE:						
Corn (Bushels)	112.89	113.11	113.90	114.65	115.35	115.99
Barley (Bushels)	51.77	51.53	51.94	52.35	52.75	53.37
Oats (Bushels)	40.42	27.54	26.80	25.98	26.69	27.18
Wheat (Bushels)	43.70	44.47	45.05	45.78	46.50	47.19
Soybeans (Bushels)	37.20	37.59	37.99	38.38	38.78	39.17
All hay (Tons)	3.32	3.36	3.41	3.45	3.50	3.54
MARKET PRICES:						
Corn ($/Bushel)	2.19	2.17	2.20	2.23	2.35	2.51
Barley ($/Bushel)	2.09	2.18	2.17	2.24	2.42	2.64
Oats ($/Bushel)	1.15	1.43	1.45	1.53	1.61	1.68
Wheat ($/Bushel)	4.07	3.40	3.44	3.51	3.79	4.03
Soybeans ($/Bushel)	5.18	5.21	5.42	5.71	6.23	7.03
All hay ($/Ton)	59.64	62.51	69.12	75.19	81.14	84.98
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	6.9	6.6	6.6	6.8	7.2	7.8
Income Above Variable Costs	3.9	3.5	3.5	3.6	3.9	4.3
Income Above Fixed Costs	1.7	1.1	1.1	1.1	1.2	1.4
ARP Payments	0.7	0.7	0.6	0.6	0.5	0.3
Net Farm Income	2.4	1.8	1.7	1.7	1.7	1.6
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	143.38	149.20	156.96	166.41
Barley	78.68	84.67	88.44	93.08	98.67	104.89
Oats	37.70	40.49	42.13	44.17	46.70	49.57
Wheat	72.18	77.46	79.65	82.93	87.27	92.53
Soybeans	55.28	59.30	61.13	63.74	67.12	71.17
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D7. Baseline Northern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.1	11.7	11.2	11.2	10.9	11.0
Sorghum	6.2	6.1	5.6	5.6	5.5	5.5
Barley	3.7	3.7	3.7	3.7	3.6	3.6
Oats	3.6	3.4	3.3	3.3	3.3	3.3
Wheat	30.7	31.6	31.3	31.2	30.1	30.0
Soybeans	6.9	6.6	6.4	6.2	6.0	5.9
All hay	14.0	13.2	12.7	12.6	12.5	12.6
Fallowed Acres	14.4	14.1	13.7	13.7	13.4	13.6
Diverted Acres	10.5	7.7	9.0	8.9	10.9	11.0
Conservation Reserve Acres	6.3	9.4	9.4	9.4	9.4	9.4
Total	108.3	107.6	106.3	105.8	105.6	105.8
PRODUCTION:						
Corn (Million Bushels)	1407.3	1323.9	1256.5	1238.1	1196.6	1184.2
Sorghum (Million Bushels)	451.6	428.5	393.9	387.8	374.8	371.3
Barley (Million Bushels)	174.7	178.2	178.6	180.6	180.1	182.2
Oats (Million Bushels)	75.9	72.4	69.8	69.2	67.5	67.8
Wheat (Million Bushels)	922.9	942.7	942.4	946.9	929.4	933.8
Soybeans (Million Bushels)	236.2	228.7	223.5	221.5	217.1	216.3
All hay (Million Tons)	28.9	27.6	27.1	27.5	27.7	28.4
YIELD PER ACRE:						
Corn (Bushels)	116.74	112.69	111.83	110.71	109.31	107.60
Sorghum (Bushels)	72.56	70.59	70.03	69.35	68.56	67.64
Barley (Bushels)	47.40	48.07	48.75	49.43	50.10	50.78
Oats (Bushels)	21.37	21.19	21.00	20.81	20.62	20.43
Wheat (Bushels)	30.09	29.84	30.15	30.37	30.90	31.15
Soybeans (Bushels)	34.10	34.63	35.15	35.68	36.21	36.73
All hay (Tons)	2.06	2.10	2.14	2.18	2.22	2.26
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.32	2.35	2.39	2.51	2.68
Sorghum ($/Bushel)	2.05	2.08	2.13	2.17	2.29	2.45
Barley ($/Bushel)	2.05	2.14	2.14	2.21	2.37	2.58
Oats ($/Bushel)	0.97	1.26	1.27	1.35	1.43	1.49
Wheat ($/Bushel)	3.88	3.09	3.11	3.16	3.45	3.68
Soybeans ($/Bushel)	5.02	5.05	5.25	5.53	6.05	6.84
All hay ($/Ton)	46.75	49.16	56.31	62.76	68.90	72.41
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	10.7	9.9	9.9	10.2	10.8	11.6
Income Above Variable Costs	6.0	4.8	4.9	5.0	5.4	5.9
Income Above Fixed Costs	2.1	0.7	0.6	0.5	0.5	0.7
ARP Payments	1.0	1.4	1.3	1.2	0.9	0.5
Net Farm Income	3.1	2.1	1.9	1.7	1.4	1.2
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	138.16	144.33	152.19	161.44
Sorghum	62.99	67.68	69.81	72.91	76.89	81.60
Barley	39.65	42.63	44.03	46.01	48.54	51.52
Oats	26.17	28.12	29.25	30.67	32.42	34.42
Wheat	45.01	48.38	50.16	52.52	55.48	58.90
Soybeans	46.46	49.88	51.67	54.05	57.06	60.55
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D6. No Chemical Lake States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.3	12.2	11.8	11.7	12.2	12.1
Barley	1.3	1.2	1.1	1.1	1.1	1.1
Oats	3.0	2.9	2.8	2.8	2.6	2.6
Wheat	4.1	4.8	5.3	5.4	5.6	5.3
Soybeans	6.2	5.5	5.1	5.1	5.2	5.9
All Hay	8.6	7.5	6.8	6.5	6.6	6.6
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.0	0.0	0.0	0.0
Conservation Reserve Acres	2.1	2.7	2.7	2.7	2.7	2.7
Total	37.6	36.6	35.6	35.2	35.8	36.2
PRODUCTION:						
Corn (Million Bushels)	1386.8	1375.4	1024.6	908.9	927.0	848.2
Barley (Million Bushels)	66.8	60.3	46.9	42.7	40.1	39.5
Oats (Million Bushels)	123.1	78.7	61.8	68.0	62.9	64.8
Wheat (Million Bushels)	180.6	211.4	196.9	188.8	184.4	171.0
Soybeans (Million Bushels)	229.1	206.1	162.9	150.5	140.7	155.1
All Hay (Million Tons)	28.7	25.2	23.3	22.5	22.9	23.4
YIELD PER ACRE:						
Corn (Bushels)	112.89	113.11	86.57	77.76	76.02	70.22
Barley (Bushels)	51.77	51.53	42.85	40.29	37.39	36.17
Oats (Bushels)	40.42	27.54	22.11	24.54	24.08	25.30
Wheat (Bushels)	43.70	44.47	37.16	34.68	33.17	32.52
Soybeans (Bushels)	37.20	37.59	31.72	29.52	27.26	26.24
All Hay (Tons)	3.32	3.36	3.41	3.45	3.50	3.54
MARKET PRICES:						
Corn ($/Bushel)	2.19	2.17	2.85	6.22	5.24	7.71
Barley ($/Bushel)	2.09	2.18	2.91	3.62	4.71	5.64
Oats ($/Bushel)	1.15	1.43	1.71	1.92	2.27	2.45
Wheat ($/Bushel)	4.07	3.40	4.13	4.93	5.42	6.03
Soybeans ($/Bushel)	5.18	5.21	7.04	10.38	20.99	13.31
All Hay ($/Ton)	59.64	62.51	70.78	92.88	97.31	106.78
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	6.9	6.6	6.8	10.5	11.4	12.5
Income Above Variable Costs	3.9	3.5	4.1	7.9	8.7	9.6
Income Above Fixed Costs	1.7	1.1	1.7	5.3	5.8	6.3
ARP Payments	0.7	0.7	0.0	0.0	0.0	0.0
Net Farm Income	2.4	1.8	1.7	5.3	5.8	6.3
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.04	139.61	109.73	102.34	96.26	98.90
Barley	78.68	84.67	83.54	87.71	93.72	102.59
Oats	37.70	40.49	40.04	42.34	46.44	52.63
Wheat	72.18	77.46	71.82	73.40	77.72	86.39
Soybeans	55.28	59.30	54.27	55.11	57.45	62.63
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D9. No Chemical Northern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.1	11.7	11.7	11.1	11.7	11.3
Sorghum	6.2	6.1	6.3	6.0	6.3	6.2
Barley	3.7	3.7	3.9	4.1	4.4	4.6
Oats	3.6	3.4	3.4	3.3	3.2	3.3
Wheat	30.7	31.6	32.0	31.1	32.2	31.8
Soybeans	6.9	6.6	6.4	6.4	6.5	6.6
All Hay	14.0	13.2	12.8	12.4	13.2	13.2
Fallowed Acres	14.4	14.1	14.0	13.3	13.7	13.6
Diverted Acres	10.5	7.7	0.0	0.0	0.0	0.0
Conservation Reserve Acres	6.3	9.4	9.4	9.4	9.4	9.4
Total	108.3	107.6	99.9	97.1	100.6	99.9
PRODUCTION:						
Corn (Million Bushels)	1407.3	1323.9	951.0	885.0	1320.1	1164.7
Sorghum (Million Bushels)	451.6	428.5	362.0	306.4	381.0	355.3
Barley (Million Bushels)	174.7	178.2	150.1	143.0	140.4	138.1
Oats (Million Bushels)	75.9	72.4	57.0	48.6	41.8	39.2
Wheat (Million Bushels)	922.9	942.7	819.7	756.1	728.4	711.0
Soybeans (Million Bushels)	236.2	228.7	188.8	175.8	164.7	161.4
All Hay (Million Tons)	28.9	27.6	27.3	27.1	29.2	29.7
YIELD PER ACRE:						
Corn (Bushels)	116.74	112.69	81.08	79.76	112.61	102.75
Sorghum (Bushels)	72.56	70.59	57.07	51.39	60.52	57.34
Barley (Bushels)	47.40	48.07	38.76	35.24	31.62	29.96
Oats (Bushels)	21.37	21.19	16.69	14.83	13.01	12.05
Wheat (Bushels)	30.09	29.84	25.63	24.28	22.69	22.37
Soybeans (Bushels)	34.10	34.63	29.35	27.44	25.45	24.61
All Hay (Tons)	2.06	2.10	2.14	2.18	2.22	2.26
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.32	2.99	6.27	5.34	7.76
Sorghum ($/Bushel)	2.05	2.08	2.41	3.62	3.61	4.89
Barley ($/Bushel)	2.05	2.14	2.82	3.48	4.50	5.37
Oats ($/Bushel)	0.97	1.26	1.55	1.75	2.11	2.28
Wheat ($/Bushel)	3.88	3.09	3.88	4.73	5.23	5.87
Soybeans ($/Bushel)	5.02	5.05	6.87	10.22	20.88	13.14
All Hay ($/Ton)	46.75	49.16	58.02	83.70	87.18	96.71
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	10.7	9.9	10.3	14.9	18.9	20.8
Income Above Variable Costs	6.0	4.8	5.4	10.0	13.5	14.8
Income Above Fixed Costs	2.1	0.7	1.1	5.3	8.2	8.8
ARP Payments	1.0	1.4	0.2	0.0	0.0	0.0
Net Farm Income	3.1	2.1	1.3	5.3	8.2	8.8
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	111.45	107.56	105.11	109.94
Sorghum	62.99	67.68	75.11	82.71	93.37	105.74
Barley	39.65	42.63	38.25	38.57	39.91	43.45
Oats	26.17	28.12	28.74	30.73	33.97	38.47
Wheat	45.01	48.38	50.21	53.80	59.24	66.47
Soybeans	46.46	49.88	44.70	45.05	46.38	50.05
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D8. No Pesticide Northern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	12.1	11.7	12.5	12.0	12.0	12.7
Sorghum	6.2	6.1	6.8	6.6	6.5	6.9
Barley	3.7	3.7	4.1	4.4	4.6	5.0
Oats	3.6	3.4	3.6	3.5	3.5	3.6
Wheat	30.7	31.6	33.9	33.9	33.9	35.2
Soybeans	6.9	6.6	6.8	6.9	7.1	7.4
All Hay	14.0	13.2	13.5	13.4	13.5	14.2
Fallowed Acres	14.4	14.1	14.8	14.4	14.5	15.2
Diverted Acres	10.5	7.7	0.0	0.0	0.0	0.0
Conservation Reserve Acres	6.3	9.4	9.4	9.4	9.4	9.4
Total	108.3	107.6	105.4	104.5	105.1	109.7
PRODUCTION:						
Corn (Million Bushels)	1407.3	1323.9	1198.5	1072.4	1092.5	1619.4
Sorghum (Million Bushels)	451.6	428.5	427.8	391.8	367.5	406.7
Barley (Million Bushels)	174.7	178.2	167.9	168.0	165.5	174.2
Oats (Million Bushels)	75.9	72.4	62.7	56.0	51.1	49.8
Wheat (Million Bushels)	922.9	942.7	896.3	867.6	828.2	837.5
Soybeans (Million Bushels)	236.2	228.7	199.3	190.5	181.9	182.7
All Hay (Million tons)	28.9	27.6	28.9	29.2	29.9	32.1
YIELD PER ACRE:						
Corn (Bushels)	116.74	112.69	96.18	89.01	91.04	127.57
Sorghum (Bushels)	72.56	70.59	63.02	59.64	56.22	59.35
Barley (Bushels)	47.40	48.07	40.95	38.35	35.67	34.53
Oats (Bushels)	21.37	21.19	17.64	16.14	14.68	13.89
Wheat (Bushels)	30.09	29.84	26.43	25.63	24.47	23.79
Soybeans (Bushels)	34.10	34.63	29.35	27.44	25.45	24.61
All Hay (Tons)	2.06	2.10	2.14	2.18	2.22	2.26
MARKET PRICES:						
Corn ($/Bushel)	2.32	2.32	2.45	2.91	4.72	3.41
Sorghum ($/Bushel)	2.05	2.08	2.05	2.22	2.79	2.83
Barley ($/Bushel)	2.05	2.14	2.36	2.58	2.96	3.27
Oats ($/Bushel)	0.97	1.26	1.40	1.53	1.70	1.83
Wheat ($/Bushel)	3.88	3.09	3.24	3.50	4.05	4.09
Soybeans ($/Bushel)	5.02	5.05	6.66	9.24	13.54	17.52
All Hay ($/Ton)	46.75	49.16	51.35	59.77	73.91	68.26
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	10.7	9.9	10.0	11.0	14.8	16.2
Income Above Variable Costs	6.0	4.8	4.7	5.6	9.0	9.6
Income Above Fixed Costs	2.1	0.7	0.4	1.0	4.1	4.2
ARP Payments	1.0	1.4	1.1	0.6	0.1	0.1
Net Farm Income	3.1	2.1	1.5	1.6	4.2	4.4
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	121.21	120.85	122.26	128.46
Sorghum	62.99	67.68	63.36	64.00	65.55	69.07
Barley	39.65	42.63	44.47	47.11	50.78	55.13
Oats	26.17	28.12	31.99	35.01	38.99	43.16
Wheat	45.01	48.38	52.37	56.26	61.48	67.31
Soybeans	46.46	49.88	44.25	43.89	44.18	46.30
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D11. No Pesticide Southern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.4	1.5	1.6	1.5	1.4	1.6
Sorghum	2.6	2.8	3.3	3.5	3.6	3.6
Barley	0.0	0.0	0.0	0.0	0.1	0.1
Oats	1.4	1.6	2.0	2.3	2.6	2.9
Wheat	13.1	13.3	15.0	14.7	14.3	14.0
Soybeans	0.7	0.8	1.0	1.2	1.3	1.0
Cotton	5.6	6.1	7.5	7.7	7.7	7.8
All Hay	5.3	5.0	5.3	5.0	4.9	4.9
Fallowed Acres	1.9	1.9	2.1	1.9	2.0	2.0
Diverted Acres	6.9	5.1	0.0	0.0	0.0	0.0
Conservation Reserve Acres	4.1	5.1	5.1	5.1	5.1	5.1
Total	43.1	43.1	42.9	42.9	42.9	43.0
PRODUCTION:						
Corn (Million Bushels)	186.1	188.5	145.7	111.6	92.2	129.1
Sorghum (Million Bushels)	142.6	145.5	157.0	156.8	151.1	159.0
Barley (Million Bushels)	0.0	0.0	0.0	1.0	2.4	3.8
Oats (Million Bushels)	10.5	8.1	11.1	13.1	15.0	16.8
Wheat (Million Bushels)	277.9	279.2	294.2	278.0	261.8	253.9
Soybeans (Million Bushels)	15.2	16.1	15.4	15.0	13.4	9.7
Cotton (Million Pounds)	2055.3	2247.2	2250.5	2098.8	1895.2	1819.6
All Hay (Million Tons)	12.1	11.6	12.3	11.7	11.6	11.7
YIELD PER ACRE:						
Corn (Bushels)	129.40	128.21	90.20	75.03	66.79	80.52
Sorghum (Bushels)	54.18	52.82	46.99	44.33	41.66	43.85
Barley (Bushels)	28.73	31.10	29.69	29.72	29.64	30.13
Oats (Bushels)	7.42	5.10	5.62	5.73	5.77	5.90
Wheat (Bushels)	21.20	21.01	19.58	18.94	18.30	18.11
Soybeans (Bushels)	20.38	20.22	14.94	12.79	10.67	9.59
Cotton (Pounds)	364.80	367.40	299.70	273.49	246.88	234.23
All Hay (Tons)	2.30	2.32	2.33	2.35	2.37	2.39
MARKET PRICES:						
Corn ($/Bushel)	2.74	2.74	2.89	3.39	5.28	3.95
Sorghum ($/Bushel)	2.34	2.39	2.36	2.55	3.13	3.19
Barley ($/Bushel)	2.64	2.75	2.93	3.12	3.42	3.67
Oats ($/Bushel)	1.79	2.04	2.18	2.33	2.51	2.66
Wheat ($/Bushel)	4.02	3.41	3.56	3.81	4.32	4.40
Soybeans ($/Bushel)	5.00	5.04	6.55	8.96	12.97	16.68
Cotton ($/Pound)	0.57	0.52	0.59	0.69	0.85	0.96
All Hay ($/Ton)	77.61	81.12	84.48	91.44	102.00	102.03
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.2	4.0	4.3	4.5	5.1	5.3
Income Above Variable Costs	2.1	1.7	1.6	1.8	2.3	2.4
Income Above Fixed Costs	1.1	0.6	0.5	0.6	1.1	1.1
ARP Payments	0.4	0.6	0.4	0.1	0.0	0.0
Net Farm Income	1.5	1.2	0.9	0.7	1.1	1.1
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	166.32	161.26	157.63	161.93
Sorghum	67.39	72.37	71.28	73.57	77.02	82.07
Barley	78.68	84.67	91.08	97.78	106.31	115.40
Oats	26.17	28.12	31.78	34.71	38.58	42.68
Wheat	46.16	49.56	52.35	55.78	60.48	65.95
Soybeans	46.46	49.88	47.44	48.52	50.46	53.76
Cotton	127.35	137.39	143.91	153.28	165.28	178.59
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D10. Baseline Southern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.4	1.5	1.4	1.3	1.2	1.2
Sorghum	2.6	2.8	2.8	2.8	2.8	2.8
Barley	0.0	0.0	0.0	0.0	0.1	0.1
Oats	1.4	1.6	1.8	2.0	2.3	2.6
Wheat	13.1	13.3	13.1	12.9	12.0	11.5
Soybeans	0.7	0.8	0.8	0.9	0.9	1.0
Cotton	5.6	6.1	6.1	6.0	6.0	6.1
All hay	5.3	5.0	4.8	4.8	4.8	4.9
Fallowed Acres	1.9	1.9	1.9	1.9	1.9	2.0
Diverted Acres	6.9	5.1	5.3	5.3	5.9	5.9
Conservation Reserve Acres	4.1	5.1	5.1	5.1	5.1	5.1
Total	43.1	43.1	43.0	43.0	43.0	43.0
PRODUCTION:						
Corn (Million Bushels)	186.1	188.5	177.2	167.6	158.6	149.4
Sorghum (Million Bushels)	142.6	145.5	145.8	144.1	141.2	137.8
Barley (Million Bushels)	0.0	0.0	0.1	0.7	1.7	3.4
Oats (Million Bushels)	10.5	8.1	10.7	11.9	13.7	15.8
Wheat (Million Bushels)	277.9	279.2	272.3	266.8	246.0	234.2
Soybeans (Million Bushels)	15.2	16.1	16.5	17.0	17.8	19.0
Cotton (Million Pounds)	2055.3	2247.2	2248.4	2253.4	2263.1	2288.3
All hay (Million Tons)	12.1	11.6	11.2	11.3	11.4	11.7
YIELD PER ACRE:						
Corn (Bushels)	129.40	128.21	128.86	129.36	129.70	129.86
Sorghum (Bushels)	54.18	52.82	52.21	51.54	50.81	50.01
Barley (Bushels)	28.73	31.10	31.59	31.87	32.33	32.99
Oats (Bushels)	7.42	5.10	5.98	5.87	5.96	6.03
Wheat (Bushels)	21.20	21.61	20.83	20.68	20.52	20.34
Soybeans (Bushels)	20.38	20.22	20.06	19.89	19.73	19.56
Cotton (Pounds)	364.80	367.40	370.00	372.60	375.20	377.80
All hay (Tons)	2.30	2.32	2.33	2.35	2.37	2.39
MARKET PRICES:						
Corn ($/Bushel)	2.74	2.74	2.79	2.84	2.98	3.17
Sorghum ($/Bushel)	2.34	2.39	2.44	2.50	2.63	2.80
Barley ($/Bushel)	2.64	2.75	2.81	2.91	3.07	3.25
Oats ($/Bushel)	1.79	2.04	2.09	2.19	2.29	2.39
Wheat ($/Bushel)	4.02	3.41	3.46	3.53	3.80	4.03
Soybeans ($/Bushel)	5.00	5.64	5.24	5.52	6.01	6.77
Cotton ($/Pound)	0.57	0.52	0.54	0.57	0.60	0.63
All hay ($/Ton)	77.61	81.12	86.97	92.51	98.17	102.47
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.2	4.0	4.1	4.2	4.4	4.6
Income Above Variable Costs	2.1	1.7	1.8	1.8	1.9	2.0
Income Above Fixed Costs	1.1	0.6	0.6	0.6	0.6	0.7
ARP Payments	0.4	0.6	0.6	0.5	0.3	0.2
Net Farm Income	1.5	1.2	1.2	1.1	1.0	0.8
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	199.59	208.55	219.93	233.32
Sorghum	67.39	72.37	74.82	78.24	82.57	87.65
Barley	78.68	84.67	88.44	93.08	98.67	104.89
Oats	26.17	28.12	29.25	30.67	32.42	34.42
Wheat	46.16	49.56	51.48	53.96	57.04	60.56
Soybeans	46.46	49.88	51.67	54.05	57.06	60.55
Cotton	127.35	137.39	143.99	151.87	161.26	171.55
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D13. Baseline Delta States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.4	0.6	0.8	0.9	1.0	1.1
Sorghum	0.5	0.6	0.6	0.6	0.6	0.6
Oats	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	2.2	2.6	2.9	3.2	3.4	3.6
Soybeans	7.2	6.8	6.4	5.9	5.5	5.2
Cotton	2.5	2.5	2.4	2.4	2.4	2.4
All hay	1.8	1.8	1.8	1.8	1.8	1.8
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	1.6	1.2	1.2	1.2	1.3	1.4
Conservation Reserve Acres	0.8	1.1	1.1	1.1	1.1	1.1
Total	17.0	17.2	17.1	17.1	17.1	17.1
PRODUCTION:						
Corn (Million Bushels)	40.2	58.8	71.9	85.1	98.2	111.7
Sorghum (Million Bushels)	36.3	41.5	42.0	41.9	41.7	41.4
Oats (Million Bushels)	1.7	0.0	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	74.8	93.0	104.8	117.0	124.8	136.2
Soybeans (Million Bushels)	170.3	161.3	150.9	140.9	131.6	123.8
Cotton (Million Pounds)	1806.1	1806.0	1765.2	1775.3	1792.7	1832.6
All hay (Million Tons)	3.5	3.6	3.5	3.6	3.6	3.7
YIELD PER ACRE:						
Corn (Bushels)	90.03	92.21	94.39	96.57	98.75	100.93
Sorghum (Bushels)	69.68	70.64	71.60	72.56	73.52	74.48
Oats (Bushels)	34.87	32.01	33.39	33.22	33.36	33.47
Wheat (Bushels)	34.47	35.53	35.53	36.12	36.70	37.79
Soybeans (Bushels)	23.71	23.71	23.71	23.71	23.71	23.71
Cotton (Pounds)	723.00	731.45	739.90	748.35	756.80	765.25
All hay (Tons)	1.98	1.99	2.00	2.01	2.02	2.03
MARKET PRICES:						
Corn ($/Bushel)	2.67	2.66	2.70	2.75	2.89	3.08
Sorghum ($/Bushel)	2.00	2.04	2.08	2.12	2.24	2.40
Oats ($/Bushel)	1.66	1.91	1.96	2.05	2.15	2.24
Wheat ($/Bushel)	3.94	3.51	3.58	3.67	3.92	4.14
Soybeans ($/Bushel)	5.52	5.57	5.79	6.09	6.62	7.42
Cotton ($/Pound)	0.65	0.61	0.63	0.66	0.70	0.72
All hay ($/Ton)	63.19	66.09	71.30	76.20	81.15	84.76
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.8	2.8	2.9	3.1	3.3	3.6
Income Above Variable Costs	1.5	1.4	1.4	1.5	1.7	1.8
Income Above Fixed Costs	0.9	0.7	0.7	0.8	0.9	1.1
ARP Payments	0.2	0.3	0.3	0.2	0.1	0.1
Net Farm Income	1.1	1.0	1.0	1.0	1.1	1.1
VARIABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	144.99	150.91	158.79	168.37
Sorghum	67.39	72.37	74.82	78.24	82.57	87.65
Oats	37.70	40.49	42.13	44.17	46.70	49.57
Wheat	70.76	76.02	78.41	81.82	86.23	91.47
Soybeans	59.34	63.73	65.85	68.80	72.55	76.98
Cotton	237.65	256.53	266.24	279.25	295.49	314.08
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D12. No Chemical Southern Plains Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.4	1.5	1.5	1.5	1.9	1.7
Sorghum	2.6	2.8	3.2	3.3	3.4	2.7
Barley	0.0	0.0	0.0	0.1	0.1	0.2
Oats	1.4	1.6	2.1	2.5	2.8	3.1
Wheat	13.1	13.3	14.7	14.1	13.7	13.4
Soybeans	0.7	0.8	1.0	1.1	0.6	0.8
Cotton	5.6	6.1	7.3	7.3	7.3	8.0
All Hay	5.3	5.0	5.1	4.8	4.8	4.7
Fallowed Acres	1.9	1.9	2.0	1.9	1.8	1.9
Diverted Acres	6.9	5.1	0.0	0.0	0.0	0.0
Conservation Reserve Acres	4.1	5.1	5.1	5.1	5.1	5.1
Total	43.1	43.1	42.0	41.7	41.5	41.6
PRODUCTION:						
Corn (Million Bushels)	186.1	188.5	127.5	106.3	147.7	117.2
Sorghum (Million Bushels)	142.6	145.5	138.0	128.2	148.0	111.4
Barley (Million Bushels)	0.0	0.0	0.0	2.3	2.6	4.4
Oats (Million Bushels)	10.5	8.1	10.5	13.4	14.4	16.9
Wheat (Million Bushels)	277.9	279.2	259.5	230.6	213.5	203.7
Soybeans (Million Bushels)	15.2	16.1	15.4	14.0	6.9	7.7
Cotton (Million Pounds)	2055.3	2247.2	1838.2	1523.4	1186.6	1111.8
All Hay (Million Tons)	12.1	11.6	12.0	11.4	11.3	11.3
YIELD PER ACRE:						
Corn (Bushels)	129.40	128.21	82.47	72.11	78.31	67.29
Sorghum (Bushels)	54.18	52.82	43.08	39.14	42.94	40.72
Barley (Bushels)	28.73	31.10	26.85	26.59	25.80	25.98
Oats (Bushels)	7.42	5.10	5.08	5.34	5.22	5.45
Wheat (Bushels)	21.20	21.01	17.71	16.35	15.64	15.20
Soybeans (Bushels)	20.38	20.22	14.94	12.79	10.67	9.59
Cotton (Pounds)	364.80	367.40	253.45	208.28	162.46	139.78
All Hay (Tons)	2.30	2.32	2.33	2.35	2.37	2.39
MARKET PRICES:						
Corn ($/Bushel)	2.74	2.74	3.45	6.89	5.95	8.49
Sorghum ($/Bushel)	2.34	2.39	2.73	3.97	3.98	5.30
Barley ($/Bushel)	2.64	2.75	3.20	3.64	4.30	4.89
Oats ($/Bushel)	1.79	2.04	2.29	2.51	2.83	3.04
Wheat ($/Bushel)	4.02	3.41	4.10	4.85	5.33	5.91
Soybeans ($/Bushel)	5.00	5.04	6.75	9.88	19.79	12.64
Cotton ($/Pound)	0.57	0.52	0.68	1.23	1.74	1.44
All Hay ($/Ton)	77.61	81.12	88.57	105.61	111.37	120.73
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.2	4.0	4.3	5.6	6.1	5.9
Income Above Variable Costs	2.1	1.7	1.7	3.0	3.7	2.6
Income Above Fixed Costs	1.1	0.6	0.6	1.7	2.4	1.2
ARP Payments	0.4	0.6	0.0	0.0	0.0	0.0
Net Farm Income	1.5	1.2	0.6	1.7	2.4	1.2
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	158.45	151.15	144.94	149.10
Sorghum	67.39	72.37	90.35	103.38	120.63	138.45
Barley	78.68	84.67	85.83	91.21	98.57	108.36
Oats	26.17	28.12	28.59	30.51	33.67	38.13
Wheat	46.16	49.56	47.11	48.82	52.06	57.67
Soybeans	46.46	49.88	47.92	49.78	52.89	57.94
Cotton	127.35	137.39	150.35	165.34	184.59	205.92
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D15. No Chemical Delta States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.4	0.6	0.9	1.1	1.4	1.4
Sorghum	0.5	0.6	0.6	0.5	0.5	0.3
Oats	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	2.2	2.6	3.2	3.5	3.8	4.0
Soybeans	7.2	6.8	6.7	6.3	5.9	6.2
Cotton	2.5	2.5	2.4	2.2	2.2	2.5
All Hay	1.8	1.8	1.8	1.7	1.7	1.8
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	1.6	1.2	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.8	1.1	1.1	1.1	1.1	1.1
Total	17.0	17.2	16.7	16.4	16.5	17.2
PRODUCTION:						
Corn (Million Bushels)	40.2	58.8	54.8	51.8	47.6	40.0
Sorghum (Million Bushels)	36.3	41.5	34.1	26.0	23.5	13.0
Oats (Million Bushels)	1.7	0.0	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	74.8	93.0	98.7	106.5	112.4	116.4
Soybeans (Million Bushels)	170.3	161.3	117.6	96.5	75.2	72.5
Cotton (Million Pounds)	1806.1	1806.0	1169.6	855.0	656.4	601.6
All Hay (Million Tons)	3.5	3.6	3.7	3.4	3.5	3.6
YIELD PER ACRE:						
Corn (Bushels)	90.03	92.21	60.41	47.90	34.76	28.26
Sorghum (Bushels)	69.68	70.64	59.07	54.78	50.36	48.41
Oats (Bushels)	34.87	32.01	28.88	28.02	26.58	26.28
Wheat (Bushels)	34.47	35.53	30.73	30.08	29.49	29.25
Soybeans (Bushels)	23.71	23.71	17.67	15.25	12.83	11.62
Cotton (Pounds)	723.00	731.45	488.33	392.13	293.64	244.88
All Hay (Tons)	1.98	1.99	2.00	2.01	2.02	2.03
MARKET PRICES:						
Corn ($/Bushel)	2.67	2.66	3.41	7.08	6.05	8.75
Sorghum ($/Bushel)	2.00	2.04	2.38	3.64	3.62	4.97
Oats ($/Bushel)	1.66	1.91	2.17	2.38	2.71	2.91
Wheat ($/Bushel)	3.94	3.51	4.08	4.71	5.13	5.65
Soybeans ($/Bushel)	5.52	5.57	7.36	10.64	20.98	13.56
Cotton ($/Pound)	0.65	0.61	0.76	1.29	1.78	1.51
All Hay ($/Ton)	63.19	66.09	72.70	88.49	93.19	101.29
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.8	2.8	2.7	3.4	4.0	3.3
Income Above Variable Costs	1.5	1.4	1.4	2.2	3.0	1.9
Income Above Fixed Costs	0.9	0.7	0.7	1.4	2.3	1.0
ARP Payments	0.2	0.3	0.0	0.0	0.0	0.0
Net Farm Income	1.1	1.0	0.7	1.4	2.3	1.0
VARIABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	103.16	91.60	80.16	78.22
Sorghum	67.39	72.37	90.35	103.38	120.63	138.45
Oats	37.70	40.49	40.11	42.44	46.56	52.76
Wheat	70.76	76.02	68.47	69.17	72.28	79.86
Soybeans	59.34	63.73	62.30	65.09	69.67	76.74
Cotton	237.65	256.53	215.13	209.10	204.64	212.91
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D14. No Pesticide Delta States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.4	0.6	0.9	1.1	1.2	1.4
Sorghum	0.5	0.6	0.6	0.6	0.5	0.5
Oats	0.0	0.0	0.0	0.0	0.0	0.0
Wheat	2.2	2.6	3.2	3.5	3.6	3.8
Soybeans	7.2	6.8	6.6	6.3	6.0	5.8
Cotton	2.5	2.5	2.4	2.2	2.1	2.1
All Hay	1.8	1.8	1.8	1.7	1.6	1.7
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	1.6	1.2	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.8	1.1	1.1	1.1	1.1	1.1
Total	17.0	17.2	16.7	16.4	16.2	16.3
PRODUCTION:						
Corn (Million Bushels)	40.2	58.8	61.1	61.0	54.0	54.6
Sorghum (Million Bushels)	36.3	41.5	41.5	35.8	30.8	27.2
Oats (Million Bushels)	1.7	0.0	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	74.8	93.0	110.1	119.9	127.0	135.9
Soybeans (Million Bushels)	170.3	161.3	117.0	95.7	77.0	67.7
Cotton (Million Pounds)	1806.1	1806.0	1351.3	1074.5	886.2	837.0
All Hay (Million Tons)	3.5	3.6	3.7	3.4	3.3	3.4
YIELD PER ACRE:						
Corn (Bushels)	90.03	92.21	66.07	56.01	45.42	40.37
Sorghum (Bushels)	69.68	70.64	64.44	62.40	60.29	59.59
Oats (Bushels)	34.87	32.01	32.22	32.14	31.96	32.04
Wheat (Bushels)	34.47	35.53	34.29	34.35	34.83	35.85
Soybeans (Bushels)	23.71	23.71	17.67	15.25	12.83	11.62
Cotton (Pounds)	723.00	731.45	558.62	491.66	423.05	390.28
All Hay (Tons)	1.98	1.99	2.00	2.01	2.02	2.03
MARKET PRICES:						
Corn ($/Bushel)	2.67	2.66	2.81	3.33	5.35	3.90
Sorghum ($/Bushel)	2.00	2.04	1.99	2.17	2.76	2.79
Oats ($/Bushel)	1.66	1.91	2.05	2.20	2.37	2.52
Wheat ($/Bushel)	3.94	3.51	3.67	3.90	4.33	4.44
Soybeans ($/Bushel)	5.52	5.57	7.15	9.67	13.86	17.74
Cotton ($/Pound)	0.65	0.61	0.67	0.77	0.93	1.04
All Hay ($/Ton)	63.19	66.09	68.84	75.04	84.61	83.93
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.8	2.8	2.7	2.8	3.1	3.3
Income Above Variable Costs	1.5	1.4	1.2	1.4	1.8	1.9
Income Above Fixed Costs	0.9	0.7	0.6	0.7	1.0	1.1
ARP Payments	0.2	0.3	0.2	0.0	0.0	0.0
Net Farm Income	1.1	1.0	0.7	0.7	1.0	1.1
VARIABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	111.55	103.07	95.24	94.90
Sorghum	67.39	72.37	71.28	73.57	77.02	82.07
Oats	37.70	40.49	46.33	50.83	56.75	62.96
Wheat	70.76	76.02	82.94	89.17	97.70	107.25
Soybeans	59.34	63.73	61.68	63.43	66.41	71.07
Cotton	237.65	256.53	232.30	232.53	235.48	246.25
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D17. No Pesticide Mountain States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	0.9	1.0	1.0	1.0	1.0
Sorghum	0.4	0.5	0.6	0.6	0.6	0.6
Barley	3.6	3.7	4.2	4.3	4.4	4.4
Oats	0.5	0.5	0.5	0.4	0.3	0.2
Wheat	11.0	11.5	13.3	13.6	13.6	13.6
Cotton	0.6	0.6	0.8	0.8	0.8	0.9
All Hay	7.7	7.4	8.1	8.1	8.1	8.3
Fallowed Acres	10.0	9.9	10.8	10.4	10.4	10.4
Diverted Acres	5.3	3.8	0.0	0.0	0.0	0.0
Conservation Reserve Acres	3.7	6.4	6.4	6.4	6.4	6.4
Total	43.7	45.2	45.7	45.7	45.7	45.8
PRODUCTION:						
Corn (Million Bushels)	163.0	150.9	115.1	94.8	77.1	90.0
Sorghum (Million Bushels)	10.8	12.1	13.2	12.4	10.9	10.0
Barley (Million Bushels)	181.9	173.7	167.9	168.9	164.8	164.8
Oats (Million Bushels)	14.5	10.4	8.1	7.5	5.7	3.3
Wheat (Million Bushels)	340.2	371.4	384.3	387.2	369.4	365.8
Cotton (Million Pounds)	647.9	758.0	791.6	771.1	751.4	792.8
All Hay (Million Tons)	21.0	20.5	22.7	22.9	23.3	23.8
YIELD PER ACRE:						
Corn (Bushels)	159.33	160.06	113.47	95.14	79.67	87.30
Sorghum (Bushels)	29.34	26.87	22.79	20.38	18.04	18.14
Barley (Bushels)	50.02	47.21	40.23	38.94	37.20	37.35
Oats (Bushels)	28.42	21.46	17.53	17.67	17.22	17.46
Wheat (Bushels)	30.95	32.32	28.89	28.52	27.13	26.80
Cotton (Pounds)	1154.74	1175.59	1034.93	987.23	937.29	919.08
All Hay (Tons)	2.74	2.77	2.80	2.83	2.86	2.89
MARKET PRICES:						
Corn ($/Bushel)	2.45	2.44	2.58	3.06	4.97	3.60
Sorghum ($/Bushel)	2.18	2.21	2.15	2.35	3.02	3.05
Barley ($/Buchel)	2.63	2.74	2.96	3.19	3.55	3.85
Oats ($/Bushel)	1.24	1.55	1.70	1.85	2.04	2.19
Wheat ($/Bushel)	3.89	3.18	3.33	3.59	4.11	4.17
Cotton ($/Pound)	0.68	0.64	0.70	0.81	0.98	1.09
All Hay ($/Ton)	74.57	78.04	81.32	89.41	102.13	100.28
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.3	4.2	4.5	4.9	5.6	5.8
Income Above Variable Costs	3.0	2.8	2.9	3.3	3.9	3.9
Income Above Fixed Costs	1.8	1.5	1.6	1.8	2.2	2.1
ARP Payments	0.2	0.4	0.2	0.1	0.0	0.0
Net Farm Income	2.0	1.9	1.8	1.9	2.2	2.1
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	104.70	96.47	88.70	88.15
Sorghum	62.99	67.68	66.26	68.17	71.16	75.70
Barley	39.65	42.63	44.47	47.11	50.78	55.13
Oats	26.17	28.12	31.99	35.01	38.99	43.16
Wheat	45.01	48.38	52.37	56.26	61.48	67.31
Cotton	0.00	0.00	21.07	34.36	50.38	61.69
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D16. Baseline Mountain States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	0.9	0.9	0.8	0.7	0.7
Sorghum	0.4	0.5	0.5	0.5	0.5	0.5
Barley	3.6	3.7	3.7	3.8	3.8	3.8
Oats	0.5	0.5	0.4	0.4	0.3	0.2
Wheat	11.0	11.5	11.7	11.9	11.4	11.3
Cotton	0.6	0.6	0.7	0.7	0.7	0.7
All hay	7.7	7.4	7.3	7.4	7.3	7.4
Fallowed Acres	10.0	9.9	9.8	9.9	9.8	9.8
Diverted Acres	5.3	3.8	4.2	4.2	5.0	5.1
Conservation Reserve Acres	3.7	6.4	6.4	6.4	6.4	6.4
Total	43.7	45.2	45.7	45.8	45.9	46.0
PRODUCTION:						
Corn (Million Bushels)	163.0	150.9	139.5	130.8	122.2	115.9
Sorghum (Million Bushels)	10.8	12.1	12.1	11.6	10.8	9.9
Barley (Million Bushels)	181.9	173.7	179.1	180.8	182.0	188.5
Oats (Million Bushels)	14.5	10.4	9.4	7.6	6.1	4.6
Wheat (Million Bushels)	340.2	371.4	382.4	389.6	380.2	379.9
Cotton (Million Pounds)	647.9	758.0	802.3	831.2	841.2	865.3
All hay (Million Tons)	21.0	20.5	20.5	20.8	21.0	21.4
YIELD PER ACRE:						
Corn (Bushels)	159.33	160.06	162.10	164.03	165.85	167.54
Sorghum (Bushels)	29.34	26.87	25.32	23.70	21.99	20.21
Barley (Bushels)	50.02	47.21	47.89	47.87	48.45	49.76
Oats (Bushels)	28.42	21.46	20.88	20.44	21.06	21.54
Wheat (Bushels)	30.95	32.32	32.58	32.87	33.37	33.67
Cotton (Pounds)	1154.74	1175.59	1196.45	1217.30	1238.16	1259.02
All hay (Tons)	2.74	2.77	2.80	2.83	2.86	2.89
MARKET PRICES:						
Corn ($/Bushel)	2.45	2.44	2.47	2.52	2.64	2.82
Sorghum ($/Bushel)	2.18	2.21	2.25	2.29	2.42	2.60
Barley ($/Bushel)	2.63	2.74	2.78	2.87	3.05	3.26
Oats ($/Bushel)	1.24	1.55	1.57	1.66	1.75	1.83
Wheat ($/Bushel)	3.89	3.18	3.21	3.27	3.55	3.78
Cotton ($/Pound)	0.68	0.64	0.66	0.70	0.73	0.76
All hay ($/Ton)	74.57	78.04	84.86	91.21	97.55	101.99
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.3	4.2	4.4	4.6	4.9	5.3
Income Above Variable Costs	3.0	2.8	3.0	3.2	3.4	3.7
Income Above Fixed Costs	1.8	1.5	1.6	1.7	1.8	1.8
ARP Payments	0.2	0.4	0.3	0.3	0.2	0.1
Net Farm Income	2.0	1.9	2.0	2.0	1.9	1.9
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	138.16	144.33	152.19	161.44
Sorghum	62.99	67.68	69.81	72.91	76.89	81.60
Barley	39.65	42.63	44.03	46.01	48.54	51.52
Oats	26.17	28.12	29.25	30.67	32.42	34.42
Wheat	45.01	48.38	50.16	52.52	55.48	58.90
Cotton	0.00	0.00	0.00	0.00	0.00	0.00
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D19. Baseline Pacific States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.2	0.2	0.2	0.2	0.2	0.2
Sorghum	0.0	0.0	0.0	0.0	0.0	0.0
Barley	1.5	1.7	1.8	1.8	1.8	1.8
Oats	0.6	0.6	0.6	0.6	0.6	0.6
Wheat	3.8	4.3	4.4	4.4	4.2	4.1
Cotton	1.3	1.3	1.3	1.2	1.2	1.2
All hay	3.4	3.4	3.3	3.3	3.3	3.3
Fallowed Acres	3.0	3.0	2.8	2.8	2.9	2.9
Diverted Acres	1.5	0.9	1.0	1.0	1.2	1.3
Conservation Reserve Acres	1.8	1.7	1.7	1.7	1.7	1.7
Total	17.2	17.2	17.1	17.1	17.1	17.1
PRODUCTION:						
Corn (Million Bushels)	42.1	43.5	42.8	43.6	44.2	45.6
Sorghum (Million Bushels)	1.4	1.6	0.6	0.6	0.6	0.7
Barley (Million Bushels)	86.9	101.8	106.4	109.1	110.8	114.4
Oats (Million Bushels)	12.8	13.4	13.1	12.8	12.6	12.7
Wheat (Million Bushels)	212.9	241.9	250.4	258.0	247.7	245.5
Cotton (Million Pounds)	1654.0	1730.5	1663.1	1639.4	1626.4	1649.4
All hay (Million Tons)	14.2	14.5	14.0	14.1	14.2	14.6
YIELD PER ACRE:						
Corn (Bushels)	177.83	179.17	181.77	184.27	186.65	188.92
Sorghum (Bushels)	92.42	91.45	91.45	91.38	91.22	90.97
Barley (Bushels)	57.23	58.59	59.53	60.18	61.09	62.30
Oats (Bushels)	21.76	21.80	21.84	21.87	21.91	21.95
Wheat (Bushels)	55.41	56.47	57.34	58.38	59.39	60.39
Cotton (Pounds)	1292.15	1300.69	1309.23	1317.76	1326.30	1334.84
All hay (Tons)	4.18	4.23	4.27	4.32	4.37	4.42
MARKET PRICES:						
Corn ($/Bushel)	3.00	3.00	3.04	3.10	3.25	3.47
Sorghum ($/Bushel)	2.68	2.73	2.78	2.85	3.00	3.21
Barley ($/Bushel)	2.84	2.96	3.00	3.10	3.29	3.52
Oats ($/Bushel)	1.37	1.73	1.75	1.85	1.96	2.04
Wheat ($/Bushel)	4.32	3.60	3.65	3.72	4.02	4.27
Cotton ($/Pound)	0.75	0.72	0.74	0.78	0.82	0.85
All hay ($/Ton)	82.46	86.38	94.87	102.72	110.45	115.59
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.7	3.8	4.0	4.2	4.4	[illegible]
Income Above Variable Costs	2.5	2.4	2.5	2.7	2.9	[illegible]
Income Above Fixed Costs	1.7	1.6	1.7	1.9	2.1	2.3
ARP Payments	0.2	0.4	0.3	0.3	0.1	0.1
Net Farm Income	1.9	2.0	2.1	2.2	2.2	2.3
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	199.59	208.55	219.93	233.32
Sorghum	147.93	158.96	165.30	173.48	183.53	194.95
Barley	66.21	71.21	73.92	77.48	81.91	86.99
Oats	26.17	28.12	29.25	30.67	32.42	34.42
Wheat	77.91	83.78	87.45	91.88	97.28	103.33
Cotton	492.99	533.14	560.79	593.12	631.11	672.03
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D18. No Chemical Mountain States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	0.9	0.9	0.9	1.0	0.9
Sorghum	0.4	0.5	0.6	0.6	0.5	0.3
Barley	3.6	3.7	4.0	3.9	3.8	3.8
Oats	0.5	0.5	0.4	0.4	0.2	0.1
Wheat	11.0	11.5	12.6	12.3	12.0	11.8
Cotton	0.6	0.6	0.7	0.7	0.8	0.9
All Hay	7.7	7.4	7.7	7.4	7.3	7.2
Fallowed Acres	10.0	9.9	10.2	9.5	9.1	9.0
Diverted Acres	5.3	3.8	0.0	0.0	0.0	0.0
Conservation Reserve Acres	3.7	6.4	6.4	6.4	6.4	6.4
Total	43.7	45.2	43.5	42.0	41.0	40.4
PRODUCTION:						
Corn (Million Bushels)	163.0	150.9	98.4	76.4	78.2	63.8
Sorghum (Million Bushels)	10.8	12.1	11.7	9.9	11.6	7.3
Barley (Million Bushels)	181.9	173.7	150.6	152.6	141.4	142.2
Oats (Million Bushels)	14.5	10.4	7.4	6.6	2.7	1.0
Wheat (Million Bushels)	340.2	371.4	348.3	325.3	298.8	286.7
Cotton (Million Pounds)	647.9	758.0	625.5	542.8	492.9	531.8
All Hay (Million Tons)	21.0	20.5	21.5	20.9	20.8	20.8
YIELD PER ACRE:						
Corn (Bushels)	159.33	160.06	103.74	85.77	81.73	68.95
Sorghum (Bushels)	29.34	26.87	20.89	17.89	24.55	22.41
Barley (Bushels)	50.02	47.21	38.07	38.67	37.35	37.69
Oats (Bushels)	28.42	21.46	16.60	17.99	17.30	17.96
Wheat (Bushels)	30.95	32.32	27.71	26.44	24.94	24.32
Cotton (Pounds)	1154.74	1175.59	879.39	765.69	647.56	591.74
All Hay (Tons)	2.74	2.77	2.80	2.83	2.86	2.89
MARKET PRICES:						
Corn ($/Bushel)	2.45	2.44	3.14	6.61	5.63	8.18
Sorghum ($/Bushel)	2.18	2.21	2.59	4.05	4.01	5.55
Barley ($/Bushel)	2.63	2.74	3.35	3.94	4.85	5.63
Oats ($/Bushel)	1.24	1.55	1.86	2.09	2.48	2.67
Wheat ($/Bushel)	3.89	3.18	3.92	4.73	5.22	5.83
Cotton ($/Pound)	0.68	0.64	0.80	1.34	1.85	1.57
All Hay ($/Ton)	74.57	78.04	86.64	108.12	113.66	123.94
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	4.3	4.2	4.6	5.7	6.0	6.4
Income Above Variable Costs	3.0	2.8	3.2	4.3	4.8	5.0
Income Above Fixed Costs	1.8	1.5	1.8	2.8	3.1	2.9
ARP Payments	0.2	0.4	0.0	0.0	0.0	0.0
Net Farm Income	2.0	1.9	1.8	2.8	3.1	2.9
VARIABLE CASH EXPENSES PER ACRE:						
Corn	124.67	133.67	96.24	84.89	73.54	71.40
Sorghum	62.99	67.68	85.28	97.85	114.49	131.58
Barley	39.65	42.63	38.25	38.57	39.91	43.45
Oats	26.17	28.12	28.74	30.73	33.97	38.47
Wheat	45.01	48.38	50.21	53.80	59.24	66.47
Cotton	0.00	0.00	-42.31	-60.81	-81.74	-97.12
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D21. No Chemical Pacific States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.2	0.2	0.2	0.2	0.2	0.2
Sorghum	0.0	0.0	0.1	0.1	0.0	0.0
Barley	1.5	1.7	1.7	1.7	1.7	1.7
Oats	0.6	0.6	0.6	0.6	0.5	0.5
Wheat	3.8	4.3	4.5	4.6	4.7	4.7
Cotton	1.3	1.3	1.3	1.3	1.3	1.3
All Hay	3.4	3.4	3.2	3.1	3.0	3.0
Fallowed Acres	3.0	3.0	2.7	2.6	2.5	2.5
Diverted Acres	1.5	0.9	0.0	0.0	0.0	0.0
Conservation Reserve Acres	1.8	1.7	1.7	1.7	1.7	1.7
Total	17.2	17.2	16.1	15.8	15.7	15.7
PRODUCTION:						
Corn (Million Bushels)	42.1	43.5	25.4	20.3	21.9	12.6
Sorghum (Million Bushels)	1.4	1.6	4.3	3.6	1.2	2.9
Barley (Million Bushels)	86.9	101.8	74.3	65.9	55.3	50.8
Oats (Million Bushels)	12.8	13.4	9.1	7.3	5.6	4.8
Wheat (Million Bushels)	212.9	241.9	184.7	161.3	139.8	129.1
Cotton (Million Pounds)	1654.0	1730.5	1287.0	1081.4	885.5	825.2
All Hay (Million Tons)	14.2	14.5	13.7	13.2	13.2	13.3
YIELD PER ACRE:						
Corn (Bushels)	177.83	179.17	116.33	96.46	88.40	74.40
Sorghum (Bushels)	92.42	91.45	75.45	68.99	72.68	69.29
Barley (Bushels)	57.23	58.59	42.57	38.08	32.60	30.29
Oats (Bushels)	21.76	21.80	15.50	12.99	10.47	9.21
Wheat (Bushels)	55.41	56.47	40.71	34.79	29.89	27.46
Cotton (Pounds)	1292.15	1300.69	962.28	828.87	693.66	627.37
All Hay (Tons)	4.18	4.23	4.27	4.32	4.37	4.42
MARKET PRICES:						
Corn ($/Bushel)	3.00	3.00	3.83	7.91	6.76	9.77
Sorghum ($/Bushel)	2.68	2.73	3.15	4.72	4.71	6.38
Barley ($/Bushel)	2.84	2.96	3.62	4.26	5.24	6.08
Oats ($/Bushel)	1.37	1.73	2.09	2.35	2.80	3.02
Wheat ($/Bushel)	4.32	3.60	4.38	5.23	5.75	6.40
Cotton ($/Pound)	0.75	0.72	0.87	1.38	1.87	1.61
All Hay ($/Ton)	82.46	86.38	97.04	124.84	130.97	143.36
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.7	3.8	3.7	4.5	4.6	4.5
Income Above Variable Costs	2.5	2.4	2.4	3.3	3.8	3.2
Income Above Fixed Costs	1.7	1.6	1.6	2.5	3.0	2.3
ARP Payments	0.2	0.4	0.0	0.0	0.0	0.0
Net Farm Income	1.9	2.0	1.6	2.5	3.0	2.3
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	158.45	151.15	144.94	149.10
Sorghum	147.93	158.96	182.06	202.04	228.41	257.40
Barley	66.21	71.21	68.24	71.03	75.64	83.06
Oats	26.17	28.12	29.60	32.04	35.67	40.27
Wheat	77.91	83.78	66.72	63.18	61.18	65.22
Cotton	492.99	533.14	526.46	553.43	588.02	637.71
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D20. Nc Pesticide Pacific States Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	0.2	0.2	0.2	0.2	0.2	0.2
Sorghum	0.0	0.0	0.1	0.1	0.1	0.0
Barley	1.5	1.7	1.8	1.9	1.9	1.9
Oats	0.6	0.6	0.6	0.6	0.6	0.6
Wheat	3.8	4.3	4.8	5.0	5.1	5.1
Cotton	1.3	1.3	1.4	1.4	1.4	1.4
All Hay	3.4	3.4	3.4	3.3	3.3	3.3
Fallowed Acres	3.0	3.0	2.9	2.8	2.8	2.8
Diverted Acres	1.5	0.9	0.0	0.0	0.0	0.0
Conservation Reserve Acres	1.8	1.7	1.7	1.7	1.7	1.7
Total	17.2	17.2	16.9	16.9	16.9	17.0
PRODUCTION:						
Corn (Million Bushels)	42.1	43.5	28.4	22.2	18.1	23.0
Sorghum (Million Bushels)	1.4	1.6	5.1	5.4	5.2	2.9
Barley (Million Bushels)	86.9	101.8	94.7	91.9	87.3	86.4
Oats (Million Bushels)	12.8	13.4	11.3	10.2	9.1	8.6
Wheat (Million Bushels)	212.9	241.9	229.4	223.6	211.4	210.5
Cotton (Million Pounds)	1654.0	1730.5	1606.6	1507.8	1408.4	1366.3
All Hay (Million Tons)	14.2	14.5	14.5	14.2	14.3	14.5
YIELD PER ACRE:						
Corn (Bushels)	177.83	179.17	127.24	106.87	90.14	95.43
Sorghum (Bushels)	92.42	91.45	82.31	78.58	74.80	76.39
Barley (Bushels)	57.23	58.59	51.20	49.14	46.83	46.34
Oats (Bushels)	21.76	21.80	18.23	16.82	15.40	14.70
Wheat (Bushels)	55.41	56.47	47.88	44.89	41.75	40.94
Cotton (pounds)	1292.15	1300.69	1132.48	1068.71	1004.01	974.43
All Hay (tons)	4.18	4.23	4.27	4.32	4.37	4.42
MARKET PRICES:						
Corn ($/Bushel)	3.00	3.00	3.17	3.74	5.99	4.38
Sorghum ($/Bushel)	2.68	2.73	2.68	2.91	3.64	3.70
Barley ($/Bushel)	2.84	2.96	3.20	3.44	3.84	4.16
Oats ($/Bushel)	1.37	1.73	1.90	2.08	2.30	2.46
Wheat ($/Bushel)	4.32	3.60	3.77	4.04	4.60	4.68
Cotton ($/Pound)	0.75	0.72	0.78	0.89	1.05	1.16
All Hay ($/Ton)	82.46	86.38	90.05	100.11	116.22	112.69
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.7	3.8	3.9	4.1	4.6	4.7
Income Above Variable Costs	2.5	2.4	2.3	2.5	3.0	3.1
Income Above Fixed Costs	1.7	1.6	1.5	1.7	2.2	2.2
ARP Payments	0.2	0.4	0.2	0.1	0.0	0.0
Net Farm Income	1.9	2.0	1.8	1.8	2.2	2.2
VARIABLE CASH EXPENSES PER ACRE:						
Corn	180.22	193.19	166.32	161.26	157.63	161.93
Sorghum	147.93	158.96	162.06	169.84	180.36	193.54
Barley	66.21	71.21	72.07	75.46	80.25	86.41
Oats	26.17	28.12	29.86	31.85	34.57	37.76
Wheat	77.91	83.78	83.62	87.22	92.62	100.17
Cotton	492.99	533.14	583.83	633.71	694.75	755.13
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D23. No Pesticide Northeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	2.7	2.9	3.0	3.0	3.0	3.1
Barley	0.2	0.2	0.2	0.2	0.1	0.1
Oats	0.6	0.6	0.5	0.5	0.5	0.5
Wheat	0.5	0.5	0.6	0.6	0.6	0.6
Soybeans	1.1	1.1	1.1	1.1	1.1	0.9
All Hay	5.5	5.3	5.2	5.2	5.2	5.2
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.1	0.2	0.2	0.2	0.2	0.2
Total	10.8	10.8	10.7	10.6	10.6	10.7
PRODUCTION:						
Corn (Million Bushels)	309.9	320.4	301.6	290.4	304.1	383.2
Barley (Million Bushels)	9.2	8.9	7.4	6.6	5.8	5.2
Oats (Million Bushels)	36.1	31.0	26.0	24.4	22.7	21.9
Wheat (Million Bushels)	21.1	22.2	20.3	19.5	18.3	19.2
Soybeans (Million Bushels)	33.2	33.0	25.7	23.3	20.5	17.0
All Hay (Million tons)	13.6	13.1	13.0	13.0	13.2	13.4
YIELD PER ACRE:						
Corn (Bushels)	113.03	109.93	101.57	98.02	102.43	122.35
Barley (Bushels)	49.20	50.93	45.38	43.73	41.94	41.49
Oats (Bushels)	59.21	55.37	49.68	48.23	46.46	46.06
Wheat (Bushels)	39.88	40.82	35.27	33.56	31.78	33.09
Soybeans (Bushels)	30.29	30.40	24.11	21.63	19.13	17.90
All Hay (Tons)	2.46	2.48	2.50	2.52	2.54	2.56
MARKET PRICES:						
Corn ($/Bushel)	2.72	2.73	2.87	3.37	5.27	3.93
Barley ($/Bushel)	2.38	2.48	2.65	2.83	3.11	3.34
Oats ($/Bushel)	1.38	1.68	1.83	1.98	2.17	2.32
Wheat ($/Bushel)	3.97	3.44	3.59	3.84	4.31	4.40
Soybeans ($/Bushel)	5.26	5.30	6.88	9.39	13.57	17.44
All Hay ($/Ton)	90.98	95.02	98.90	105.96	116.29	117.81
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.4	2.4	2.5	2.7	3.6	3.5
Income Above Variable Costs	1.5	1.5	1.5	1.7	2.5	2.4
Income Above Fixed Costs	0.8	0.7	0.7	0.8	1.5	1.3
ARP Payments	0.1	0.1	0.0	0.0	0.0	0.0
Net Farm Income	0.8	0.8	0.7	0.8	1.5	1.3
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	133.56	136.11	141.06	150.12
Barley	65.91	70.93	79.62	86.73	95.98	105.73
Oats	71.63	77.17	81.84	87.24	94.47	102.86
Wheat	77.91	83.78	91.95	99.47	109.69	121.21
Soybeans	55.28	59.30	53.26	52.99	53.64	56.55
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D22. Baseline Northeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	2.7	2.9	2.9	3.0	3.0	2.9
Barley	0.2	0.2	0.2	0.1	0.1	0.1
Oats	0.6	0.6	0.5	0.5	0.5	0.5
Wheat	0.5	0.5	0.5	0.5	0.5	0.4
Soybeans	1.1	1.1	1.1	1.1	1.1	1.1
All hay	5.5	5.5	5.2	5.1	5.1	5.2
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.1	0.1	0.1	0.1
Conservation Reserve Acres	0.1	0.2	0.2	0.2	0.2	0.2
Total	10.8	10.8	10.7	10.7	10.6	10.6
PRODUCTION:						
Corn (Million Bushels)	309.9	320.4	323.9	323.8	322.0	318.7
Barley (Million Bushels)	9.2	8.9	8.3	7.7	7.1	6.5
Oats (Million Bushels)	36.1	31.0	30.2	29.3	29.0	29.0
Wheat (Million Bushels)	21.1	22.2	21.5	21.3	19.3	18.2
Soybeans (Million Bushels)	33.2	33.0	32.7	32.8	33.3	34.2
All hay (Million Tons)	13.6	13.1	12.9	13.0	13.1	13.2
YIELD PER ACRE:						
Corn (Bushels)	113.03	109.93	109.80	109.52	109.06	108.42
Barley (Bushels)	49.20	50.93	51.57	52.06	52.68	53.47
Oats (Bushels)	59.21	55.37	56.45	56.82	57.75	58.60
Wheat (Bushels)	39.88	40.82	40.08	40.33	40.54	40.72
Soybeans (Bushels)	30.29	30.40	30.52	30.64	30.75	30.87
All hay (Tons)	2.46	2.48	2.50	2.52	2.54	2.56
MARKET PRICES:						
Corn ($/Bushel)	2.72	2.73	2.77	2.83	2.96	3.15
Barley ($/Bushel)	2.38	2.48	2.52	2.61	2.76	2.93
Oats ($/Bushel)	1.38	1.68	1.71	1.80	1.90	1.98
Wheat ($/Bushel)	3.97	3.44	3.50	3.58	3.84	4.06
Soybeans ($/Bushel)	5.26	5.30	5.51	5.81	6.32	7.11
All hay ($/Ton)	90.98	95.02	100.91	106.59	112.51	117.30
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.4	2.4	2.5	2.6	2.8	2.9
Income Above Variable Costs	1.5	1.5	1.6	1.6	1.7	1.8
Income Above Fixed Costs	0.8	0.7	0.7	0.7	0.8	0.8
ARP Payments	0.1	0.1	0.1	0.1	0.0	0.0
Net Farm Income	0.8	0.8	0.8	0.8	0.8	0.8
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	144.97	151.42	159.71	169.48
Barley	65.91	70.93	74.08	77.89	82.52	87.68
Oats	71.63	77.17	80.53	84.67	89.71	95.35
Wheat	77.91	83.78	87.45	91.88	97.28	103.33
Soybeans	55.28	59.30	61.13	63.74	67.12	71.17
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D25. Baseline Appalachian Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	3.8	4.2	4.3	4.3	4.3	4.2
Sorghum	0.4	0.7	0.8	1.0	1.0	1.0
Barley	0.1	0.1	0.1	0.1	0.0	0.0
Oats	0.1	0.0	0.0	0.0	0.0	0.0
Wheat	1.9	1.9	1.9	1.9	1.9	1.9
Soybeans	5.0	5.0	5.0	5.2	5.4	5.7
Cotton	0.7	0.7	0.6	0.6	0.6	0.6
All hay	6.3	6.0	5.9	5.9	5.9	5.9
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.5	0.4	0.6	0.6	0.6	0.6
Conservation Reserve Acres	0.9	1.1	1.1	1.1	1.1	1.1
Total	19.8	20.1	20.4	20.6	20.8	20.9
PRODUCTION:						
Corn (Million Bushels)	388.6	429.6	436.7	439.6	435.3	425.4
Sorghum (Million Bushels)	25.8	45.7	57.4	64.8	68.2	68.4
Barley (Million Bushels)	5.3	4.6	3.8	2.5	0.8	0.0
Oats (Million Bushels)	2.6	0.6	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	55.9	56.1	54.6	54.3	53.6	53.7
Soybeans (Million Bushels)	127.3	127.3	128.8	132.5	137.4	144.7
Cotton (Million Pounds)	369.9	362.0	355.7	349.3	339.4	326.6
All hay (Million Tons)	11.2	10.7	10.5	10.5	10.6	10.6
YIELD PER ACRE:						
Corn (Bushels)	102.11	101.29	101.72	102.05	102.27	102.36
Sorghum (Bushels)	69.24	68.24	68.13	67.94	67.68	67.34
Barley (Bushels)	37.33	40.28	40.53	40.51	40.73	41.23
Oats (Bushels)	20.82	20.55	20.66	20.65	20.66	20.67
Wheat (Bushels)	28.69	28.97	28.29	28.15	28.00	28.21
Soybeans (Bushels)	25.59	25.59	25.59	25.59	25.59	25.59
Cotton (Pounds)	542.81	546.14	549.46	552.78	556.11	559.43
All hay (Tons)	1.77	1.78	1.78	1.79	1.79	1.80
MARKET PRICES:						
Corn ($/Bushel)	2.58	2.58	2.62	2.67	2.80	2.98
Sorghum ($/Bushel)	2.04	2.08	2.12	2.17	2.29	2.45
Barley ($/Bushel)	2.40	2.50	2.55	2.64	2.79	2.95
Oats ($/Bushel)	1.61	1.87	1.91	2.00	2.10	2.19
Wheat ($/Bushel)	3.93	3.48	3.54	3.63	3.88	4.10
Soybeans ($/Bushel)	5.47	5.52	5.74	6.04	6.56	7.35
Cotton ($/Pound)	0.66	0.62	0.64	0.67	0.71	0.73
All hay ($/Ton)	83.03	86.64	91.10	95.50	100.22	104.36
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.2	3.3	3.4	3.6	3.8	4.1
Income Above Variable Costs	1.6	1.6	1.7	1.8	1.9	2.1
Income Above Fixed Costs	0.3	0.2	0.2	0.2	0.3	0.3
ARP Payments	0.2	0.2	0.2	0.2	0.1	0.0
Net Farm Income	0.5	0.4	0.4	0.4	0.4	0.4
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	144.97	151.42	159.71	169.48
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00
Barley	65.91	70.93	74.08	77.89	82.52	87.68
Oats	71.63	77.17	80.53	84.67	89.71	95.35
Wheat	77.91	83.78	87.45	91.88	97.28	103.33
Soybeans	55.28	59.30	61.13	63.74	67.12	71.17
Cotton	277.35	299.12	308.95	323.09	341.20	362.43
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D24. No Chemical Northeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	2.7	2.9	2.9	2.9	3.1	3.1
Barley	0.2	0.2	0.2	0.1	0.1	0.1
Oats	0.6	0.6	0.5	0.5	0.5	0.5
Wheat	0.5	0.5	0.6	0.6	0.6	0.6
Soybeans	1.1	1.1	1.1	1.1	1.0	1.1
All Hay	5.5	5.3	5.2	5.1	5.2	5.3
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.0	0.0	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.1	0.2	0.2	0.2	0.2	0.2
Total	10.8	10.8	10.7	10.6	10.7	10.8
PRODUCTION:						
Corn (Million Bushels)	309.9	320.4	222.0	207.6	258.1	225.1
Barley (Million Bushels)	9.2	8.9	6.9	6.0	5.2	4.6
Oats (Million Bushels)	36.1	31.0	24.6	23.0	20.5	20.0
Wheat (Million Bushels)	21.1	22.2	19.1	18.6	18.7	18.8
Soybeans (Million Bushels)	33.2	33.0	26.5	24.0	18.2	18.8
All Hay (Million Tons)	13.6	13.1	13.0	13.0	13.3	13.5
YIELD PER ACRE:						
Corn (Bushels)	113.03	109.93	75.77	70.89	82.53	73.80
Barley (Bushels)	49.20	50.93	42.55	40.40	37.78	36.94
Oats (Bushels)	59.21	55.37	46.57	44.73	41.74	41.01
Wheat (Bushels)	39.88	40.82	33.07	31.66	31.46	31.34
Soybeans (Bushels)	30.29	30.40	24.11	21.63	19.13	17.90
All Hay (Tons)	2.46	2.48	2.50	2.52	2.54	2.56
MARKET PRICES:						
Corn ($/Bushel)	2.72	2.73	3.44	6.88	5.93	8.47
Barley ($/Bushel)	2.38	2.48	2.91	3.35	4.00	4.57
Oats ($/Bushel)	1.38	1.68	1.98	2.21	2.58	2.78
Wheat ($/Bushel)	3.97	3.44	4.07	4.77	5.23	5.78
Soybeans ($/Bushel)	5.26	5.30	7.09	10.35	20.68	13.23
All Hay ($/Ton)	90.98	95.02	102.59	118.51	125.26	135.21
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	2.4	2.4	2.4	3.4	3.7	4.2
Income Above Variable Costs	1.5	1.5	1.6	2.5	2.8	3.2
Income Above Fixed Costs	0.8	0.7	0.7	1.6	1.8	2.0
ARP Payments	0.1	0.1	0.0	0.0	0.0	0.0
Net Farm Income	0.8	0.8	0.7	1.6	1.8	2.0
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	109.68	102.16	95.70	98.02
Barley	65.91	70.93	71.46	75.92	83.03	93.22
Oats	71.63	77.17	71.58	73.32	77.07	84.71
Wheat	77.91	83.78	77.94	80.39	86.29	97.43
Soybeans	55.28	59.30	53.28	53.64	55.44	60.25
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D27. No Chemical Appalachian Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	3.8	4.2	4.6	4.6	5.5	4.9
Sorghum	0.4	0.7	0.9	1.0	1.1	0.8
Barley	0.1	0.1	0.1	0.1	0.0	0.0
Oats	0.1	0.0	0.0	0.0	0.0	0.0
Wheat	1.9	1.9	1.9	1.9	1.8	1.8
Soybeans	5.0	5.0	5.3	5.7	5.1	6.2
Cotton	0.7	0.7	0.6	0.6	0.6	0.6
All Hay	6.3	6.0	5.8	5.7	5.7	5.8
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.5	0.4	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.9	1.1	1.1	1.1	1.1	1.1
Total	19.8	20.1	20.3	20.5	20.9	21.2
PRODUCTION:						
Corn (Million Bushels)	388.6	429.6	297.1	255.0	319.1	245.1
Sorghum (Million Bushels)	25.8	45.7	50.2	48.1	58.4	40.3
Barley (Million Bushels)	5.3	4.8	3.2	1.9	0.2	0.0
Oats (Million Bushels)	2.6	0.6	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	55.9	56.1	46.8	43.9	41.9	40.5
Soybeans (Million Bushels)	127.3	127.3	107.1	103.0	81.8	92.4
Cotton (Million Pounds)	369.9	362.0	245.3	192.8	155.9	143.7
All Hay (Million Tons)	11.2	10.7	10.4	10.2	10.2	10.3
YIELD PER ACRE:						
Corn (Bushels)	102.11	101.29	65.10	55.58	58.43	49.92
Sorghum (Bushels)	69.24	68.24	55.52	50.34	54.35	51.55
Barley (Bushels)	37.33	40.28	35.06	34.76	33.79	33.99
Oats (Bushels)	20.82	20.55	17.88	16.84	15.75	15.24
Wheat (Bushels)	28.69	28.97	24.47	23.53	22.80	22.28
Soybeans (Bushels)	25.59	25.59	20.21	18.06	15.91	14.84
Cotton (Pounds)	542.81	546.14	387.37	324.49	260.81	229.37
All Hay (Tons)	1.77	1.78	1.78	1.79	1.79	1.80
MARKET PRICES:						
Corn ($/Bushel)	2.58	2.58	3.30	6.83	5.83	8.43
Sorghum ($/Bushel)	2.04	2.08	2.42	3.66	3.64	4.96
Barley ($/Bushel)	2.40	2.50	2.90	3.31	3.91	4.44
Oats ($/Bushel)	1.61	1.87	2.12	2.33	2.66	2.86
Wheat ($/Bushel)	3.93	3.48	4.06	4.71	5.14	5.67
Soybeans ($/Bushel)	5.47	5.52	7.30	10.54	20.76	13.42
Cotton ($/Pound)	0.66	0.62	0.78	1.33	1.86	1.56
All Hay ($/Ton)	83.03	86.64	92.46	103.10	109.26	117.35
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.2	3.3	3.2	4.5	5.4	5.2
Income Above Variable Costs	1.6	1.6	1.7	3.0	3.9	3.5
Income Above Fixed Costs	0.3	0.2	0.3	1.4	2.2	1.6
ARP Payments	0.2	0.2	0.0	0.0	0.0	0.0
Net Farm Income	0.5	0.4	0.3	1.4	2.2	1.6
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	112.32	105.99	100.90	104.25
Sorghum	0.00	0.00	4.39	7.31	11.64	15.98
Barley	65.91	70.93	69.89	73.73	80.14	89.81
Oats	71.63	77.17	70.61	72.10	75.62	83.09
Wheat	77.91	83.78	77.66	79.82	84.92	94.81
Soybeans	55.28	59.30	53.28	53.64	55.44	60.25
Cotton	277.35	299.12	223.95	202.59	180.64	177.42
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Appendix Table D26. No Pesticide Appalachian Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	3.8	4.2	4.7	4.7	4.6	5.1
Sorghum	0.4	0.7	1.0	1.1	1.1	1.1
Barley	0.1	0.1	0.1	0.1	0.0	0.0
Oats	0.1	0.0	0.0	0.0	0.0	0.0
Wheat	1.9	1.9	1.9	1.9	1.8	1.8
Soybeans	5.0	5.0	5.1	5.4	5.9	5.8
Cotton	0.7	0.7	0.6	0.6	0.6	0.5
All Hay	6.3	6.0	5.9	5.7	5.7	5.7
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.5	0.4	0.0	0.0	0.0	0.0
Conservation Reserve Acres	0.9	1.1	1.1	1.1	1.1	1.1
Total	19.8	20.1	20.3	20.5	20.7	21.0
PRODUCTION:						
Corn (Million Bushels)	388.6	429.6	364.1	319.1	288.6	375.5
Sorghum (Million Bushels)	25.8	45.7	59.8	64.8	62.3	60.1
Barley (Million Bushels)	5.3	4.8	3.6	2.3	0.6	0.0
Oats (Million Bushels)	2.6	0.6	0.0	0.0	0.0	0.0
Wheat (Million Bushels)	55.9	56.1	52.2	49.9	48.2	47.9
Soybeans (Million Bushels)	127.3	127.3	103.1	98.0	93.3	85.6
Cotton (Million Pounds)	369.9	362.0	281.0	239.9	201.5	182.5
All Hay (Million Tons)	11.2	10.7	10.4	10.2	10.2	10.2
YIELD PER ACRE:						
Corn (Bushels)	102.11	101.29	77.82	68.48	63.18	73.88
Sorghum (Bushels)	69.24	68.24	61.31	58.43	55.50	56.75
Barley (Bushels)	37.33	40.28	39.11	39.24	39.25	39.81
Oats (Bushels)	20.82	20.55	19.94	19.68	19.42	19.30
Wheat (Bushels)	28.69	28.97	27.30	26.77	26.55	26.96
Soybeans (Bushels)	25.59	25.59	20.21	18.06	15.91	14.84
Cotton (Pounds)	542.81	546.14	439.57	398.01	355.91	335.66
All Hay (Tons)	1.77	1.78	1.78	1.79	1.79	1.80
MARKET PRICES:						
Corn ($/Bushel)	2.58	2.58	2.73	3.22	5.16	3.77
Sorghum ($/Bushel)	2.04	2.08	2.04	2.22	2.80	2.83
Barley ($/Bushel)	2.40	2.50	2.67	2.84	3.10	3.33
Oats ($/Bushel)	1.61	1.87	2.00	2.15	2.32	2.47
Wheat ($/Bushel)	3.93	3.48	3.63	3.86	4.30	4.41
Soybeans ($/Bushel)	5.47	5.52	7.09	9.58	13.72	17.56
Cotton ($/Pound)	0.66	0.62	0.68	0.79	0.96	1.07
All Hay ($/Ton)	83.03	86.64	90.14	95.52	102.99	105.81
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	3.2	3.3	3.2	3.5	4.4	4.6
Income Above Variable Costs	1.6	1.6	1.6	1.9	2.8	2.8
Income Above Fixed Costs	0.3	0.2	0.1	0.3	1.1	1.0
ARP Payments	0.2	0.2	0.1	0.0	0.0	0.0
Net Farm Income	0.5	0.4	0.2	0.3	1.1	1.0
VARIABLE CASH EXPENSES PER ACRE:						
Corn	130.55	140.36	125.74	124.55	125.09	130.88
Sorghum	0.00	0.00	-6.67	-9.63	-12.99	-15.36
Barley	65.91	70.93	81.00	88.83	98.90	109.22
Oats	71.63	77.17	84.82	91.73	100.73	110.37
Wheat	77.91	83.78	92.02	99.46	109.39	120.41
Soybeans	55.28	59.30	53.26	52.99	53.64	56.55
Cotton	277.35	299.12	245.84	233.83	223.38	226.13
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D29. No Pesticide Southeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	1.2	1.7	1.7	1.7	2.4
Sorghum	0.3	0.3	0.3	0.3	0.3	0.3
Barley	0.0	0.0	0.0	0.0	0.0	0.0
Oats	0.2	0.2	0.2	0.1	0.1	0.2
Wheat	1.6	1.8	1.9	2.1	2.2	2.5
Soybeans	3.1	3.0	2.9	2.8	3.1	3.1
Cotton	0.7	0.6	0.5	0.4	0.3	0.2
All Hay	1.6	1.4	1.3	1.3	1.4	1.5
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.7	0.5	0.0	0.0	0.0	0.0
Conservation Reserve Acres	1.2	1.6	1.6	1.6	1.6	1.6
Total	10.5	10.5	10.4	10.4	10.7	11.7
PRODUCTION:						
Corn (Million Bushels)	81.6	99.8	133.7	144.5	153.4	232.7
Sorghum (Million Bushels)	13.9	12.5	11.2	10.7	10.4	11.0
Barley (Million Bushels)	0.8	0.9	0.8	0.8	0.8	0.8
Oats (Million Bushels)	6.0	4.7	4.3	4.1	4.1	4.4
Wheat (Million Bushels)	37.5	43.6	42.5	43.8	46.9	55.4
Soybeans (Million Bushels)	70.4	68.0	50.8	44.9	43.1	40.4
Cotton (Million pounds)	513.7	442.4	294.4	222.7	160.2	108.9
All Hay (Million tons)	3.4	3.1	2.9	2.9	3.0	3.3
YIELD PER ACRE:						
Corn (Bushels)	76.35	77.45	97.29	106.42	116.30	124.87
Sorghum (Bushels)	53.47	53.38	48.38	46.51	44.60	44.52
Barley (Bushels)	0.00	0.00	0.00	0.00	0.00	0.00
Oats (Bushels)	23.45	23.01	23.42	24.11	24.70	25.47
Wheat (Bushels)	25.03	26.23	23.89	23.59	24.02	26.08
Soybeans (Bushels)	23.06	23.06	18.22	16.28	14.35	13.38
Cotton (Pounds)	707.68	719.95	585.78	536.04	484.34	461.44
All Hay (Tons)	1.91	1.92	1.94	1.95	1.96	1.97
MARKET PRICES:						
Corn ($/Bushel)	2.39	2.38	2.51	3.00	4.92	3.53
Sorghum ($/Bushel)	2.04	2.07	2.01	2.20	2.85	2.87
Barley ($/Bushel)	0.00	0.00	0.00	0.00	0.00	0.00
Oats ($/Bushel)	1.50	1.79	1.94	2.09	2.28	2.43
Wheat ($/Bushel)	3.92	3.45	3.60	3.84	4.28	4.39
Soybeans ($/Bushel)	5.31	5.35	6.93	9.45	13.64	17.52
Cotton ($/Pound)	0.63	0.58	0.65	0.76	0.94	1.06
All Hay ($/Ton)	78.37	81.77	85.08	90.18	97.27	99.90
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	1.4	1.3	1.3	1.5	2.1	2.3
Income Above Variable Costs	0.4	0.3	0.3	0.4	0.6	0.7
Income Above Fixed Costs	0.2	0.1	0.1	0.3	0.8	0.8
ARP Payments	0.1	0.1	0.1	0.0	0.0	0.0
Net Farm Income	0.4	0.3	0.3	0.3	0.8	0.8
VARIABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	138.87	142.89	149.50	159.61
Sorghum	67.39	72.37	71.28	73.57	77.02	82.07
Barley	78.68	84.67	91.73	98.75	107.63	116.97
Oats	37.70	40.49	46.28	50.81	56.80	63.09
Wheat	70.76	76.02	82.94	89.17	97.70	107.25
Soybeans	74.63	80.22	74.88	75.69	77.76	82.29
Cotton	277.35	299.12	245.84	233.83	223.38	226.13
All Hay	65.77	70.53	73.60	77.81	83.33	89.80

Appendix Table D28. Baseline Southeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	1.2	1.1	1.0	0.9	0.7
Sorghum	0.3	0.3	0.3	0.3	0.2	0.2
Barley	0.0	0.0	0.0	0.0	0.0	0.0
Oats	0.2	0.2	0.2	0.2	0.2	0.1
Wheat	1.6	1.8	2.0	2.1	2.2	2.3
Soybeans	3.1	3.0	2.9	2.8	2.8	2.8
Cotton	0.7	0.6	0.6	0.5	0.5	0.4
All hay	1.6	1.4	1.3	1.3	1.2	1.2
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.7	0.5	0.5	0.5	0.6	0.6
Conservation Reserve Acres	1.2	1.6	1.6	1.6	1.6	1.6
Total	10.5	10.5	10.4	10.3	10.2	10.1
PRODUCTION:						
Corn (Million Bushels)	81.6	99.8	91.7	85.8	77.3	64.8
Sorghum (Million Bushels)	13.9	12.5	12.1	11.8	11.5	11.3
Barley (Million Bushels)	0.8	0.9	0.9	0.8	0.8	0.8
Oats (Million Bushels)	6.0	4.7	4.7	4.6	4.5	4.5
Wheat (Million Bushels)	37.5	43.6	44.6	47.5	48.5	51.5
Soybeans (Million Bushels)	70.4	68.0	65.4	63.9	62.5	63.7
Cotton (Million Pounds)	513.7	442.4	408.8	388.0	365.7	347.6
All hay (Million Tons)	3.4	3.1	3.0	2.9	2.8	2.8
YIELD PER ACRE:						
Corn (Bushels)	76.35	77.45	78.78	80.08	81.36	82.63
Sorghum (Bushels)	53.47	53.38	53.75	54.09	54.39	54.64
Barley (Bushels)	0.00	0.00	0.00	0.00	0.00	0.00
Oats (Bushels)	23.45	23.01	24.27	24.94	25.83	26.70
Wheat (Bushels)	25.03	26.23	24.76	24.80	24.79	25.71
Soybeans (Bushels)	23.06	23.06	23.06	23.06	23.06	23.06
Cotton (Pounds)	707.68	719.95	732.23	744.51	756.79	769.06
All hay (Tons)	1.91	1.92	1.94	1.95	1.96	1.97
MARKET PRICES:						
Corn ($/Bushel)	2.39	2.38	2.41	2.45	2.57	2.75
Sorghum ($/Bushel)	2.04	2.07	2.11	2.15	2.27	2.44
Barley ($/Bushel)	0.00	0.00	0.00	0.00	0.00	0.00
Oats ($/Bushel)	1.50	1.79	1.82	1.92	2.01	2.10
Wheat ($/Bushel)	3.92	3.45	3.52	3.68	3.85	4.07
Soybeans ($/Bushel)	5.31	5.35	5.56	5.86	6.38	7.17
Cotton ($/Pound)	0.63	0.58	0.60	0.63	0.67	0.70
All hay ($/Ton)	78.37	81.77	86.01	90.17	94.64	98.56
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	1.4	1.3	1.3	1.3	1.4	1.4
Income Above Variable Costs	0.4	0.3	0.3	0.3	0.4	0.4
Income Above Fixed Costs	0.2	0.1	0.1	0.1	0.1	0.1
ARP Payments	0.1	0.1	0.1	0.1	0.1	0.1
Net Farm Income	0.4	0.3	0.3	0.2	0.2	0.2
VAI IABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	144.99	150.91	158.79	168.37
Sorghum	67.39	72.37	74.82	78.24	82.57	87.65
Barley	78.68	84.67	88.44	93.08	98.67	104.89
Oats	37.70	40.49	42.13	44.17	46.70	49.57
Wheat	70.76	76.02	78.41	81.82	86.23	91.47
Soybeans	74.63	80.22	82.67	86.25	90.89	96.43
Cotton	277.35	299.12	308.95	323.09	341.20	362.43
All hay	65.77	70.53	73.37	77.00	81.44	86.49

Appendix Table D30. No Chemical Southeast Regional Statistics

ITEMS	1989	1990	1991	1992	1993	1994
LAND USE (MILLION ACRES):						
Corn	1.0	1.2	1.3	1.1	1.6	0.3
Sorghum	0.3	0.3	0.3	0.3	0.2	0.2
Barley	0.0	0.0	0.0	0.0	0.0	0.0
Oats	0.2	0.2	0.2	0.2	0.2	0.2
Wheat	1.6	1.8	1.9	2.0	2.1	2.3
Soybeans	3.1	3.0	3.2	3.4	3.0	4.2
Cotton	0.7	0.6	0.5	0.4	0.4	0.6
All Hay	1.6	1.4	1.3	1.2	1.2	1.3
Fallowed Acres	0.0	0.0	0.0	0.0	0.0	0.0
Diverted Acres	0.7	0.5	0.0	0.0	0.0	0.0
Conservation Reserve Acres	1.2	1.6	1.6	1.6	1.6	1.6
Total	10.5	10.5	10.2	10.1	10.3	10.7
PRODUCTION:						
Corn (Million Bushels)	81.6	99.8	73.2	50.2	56.4	7.2
Sorghum (Million Bushels)	13.9	12.5	9.9	8.5	7.9	6.9
Barley (Million Bushels)	0.8	0.9	0.7	0.7	0.6	0.6
Oats (Million Bushels)	6.0	4.7	4.1	4.0	3.9	4.3
Wheat (Million Bushels)	37.5	43.6	37.6	39.7	43.6	47.9
Soybeans (Million Bushels)	70.4	68.0	56.7	53.5	41.6	55.0
Cotton (Million Pounds)	513.7	442.4	255.9	177.9	159.7	203.6
All Hay (Million Tons)	3.4	3.1	2.9	2.7	2.7	2.9
YIELD PER ACRE:						
Corn (Bushels)	76.35	77.45	50.41	40.43	32.56	26.84
Sorghum (Bushels)	53.47	53.38	44.34	40.84	42.12	40.26
Barley (Bushels)	0.00	0.00	0.00	0.00	0.00	0.00
Oats (Bushels)	23.45	23.01	20.99	20.99	20.47	20.73
Wheat (Bushels)	25.03	26.23	21.42	22.05	23.41	23.80
Soybeans (Bushels)	23.06	23.06	18.22	16.28	14.35	13.38
Cotton (Pounds)	707.68	719.95	516.22	437.03	354.93	315.32
All Hay (Tons)	1.91	1.92	1.94	1.95	1.96	1.97
MARKET PRICES:						
Corn ($/Bushel)	2.39	2.38	3.08	6.59	5.59	8.16
Sorghum ($/Bushel)	2.04	2.07	2.44	3.83	3.80	5.28
Barley ($/Bushel)	0.00	0.00	0.00	0.00	0.00	0.00
Oats ($/Bushel)	1.50	1.79	2.08	2.31	2.67	2.88
Wheat ($/Bushel)	3.92	3.45	4.04	4.69	5.13	5.66
Soybeans ($/Bushel)	5.31	5.35	7.14	10.41	20.77	13.30
Cotton ($/Pound)	0.63	0.58	0.75	1.34	1.90	1.58
All Hay ($/Ton)	78.37	81.77	87.29	97.42	103.23	110.89
INCOME AND EXPENSES (BILLION DOLLARS):						
Gross Receipts	1.4	1.3	1.3	1.6	2.1	1.8
Income Above Variable Costs	0.4	0.3	0.4	0.7	1.1	0.7
Income Above Fixed Costs	0.2	0.1	0.2	0.6	0.9	0.5
ARP Payments	0.1	0.1	0.0	0.0	0.0	0.0
Net Farm Income	0.4	0.3	0.2	0.6	0.9	0.5
VARIABLE CASH EXPENSES PER ACRE:						
Corn	131.43	141.17	112.30	105.34	99.60	102.41
Sorghum	67.39	72.37	90.35	103.38	120.63	138.45
Barley	78.68	84.67	86.55	92.26	100.01	110.09
Oats	37.70	40.49	31.67	30.16	29.93	32.92
Wheat	70.76	76.02	68.47	69.17	72.28	79.86
Soybeans	74.63	80.22	75.12	76.87	80.36	87.21
Cotton	277.35	299.12	223.95	202.59	180.64	177.42
All Hay	65.77	70.53	74.33	79.71	86.87	95.76

Senator SYMMS. Now, gentlemen, I welcome all of you here this morning. Gentlemen, the chairman would like to have us all try to make our remarks within 5 minutes. So, I hope you will do your best to do that. We will place your prepared statements in the record, and we will all carefully look at them. But if Mr. Miller could now begin with his opening statement, followed by Mr. Pesek, then we will be able to proceed to the question period. So, please commence.

STATEMENT OF FRED P. MILLER, PH.D., DEPARTMENT OF AGRONOMY, OHIO STATE UNIVERSITY, AND MEMBER, COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY, ACCOMPANIED BY VIRGIL W. HAYS, PH.D., DEPARTMENT OF ANIMAL SCIENCE, UNIVERSITY OF KENTUCKY, AND MEMBER, COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY; AND VERNON W. RUTTAN, PH.D., DEPARTMENT OF AGRICULTURAL AND APPLIED ECONOMICS, UNIVERSITY OF MINNESOTA, AND MEMBER, COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

Mr. MILLER. Thank you very much, Senator Symms. We are, indeed, pleased to have the opportunity to appear before this committee to respond to the council's report on Alternative Agriculture. As you have already allowed, we respectfully request that our prepared statement and the CAST review of the report be entered into the record, and we also request permission to amend and extend our comments.

The Council for Agricultural Science and Technology is a consortium of 29 agricultural science societies. It was requested to undertake a review of the methodology and findings of the recently published NRC study on Alternative Agriculture. In Congressman Hamilton's letter to CAST, he indicated and requested that with a large enough panel of CAST members he indicated I am certain that we would receive a comprehensive review. In response to this request, 44 scientists and specialists reviewed the report and contributed 41 reviews to this document. This document, therefore, is a result of the coordinated effort by these experts from various agricultural disciplines and specialties.

CAST followed its long-established policy of selecting credentialed and highly qualified individuals to make this response, including those who are not members of CAST. The reviewers' comments were not changed by CAST except for agreed-upon minor editorial changes. All statements made in each individual review reflect the viewpoints of the author. The opinions in this document do not represent those of CAST, its officers, the member scientific societies, or any public or private institutions associated with either CAST or the reviewers.

Now, at the outset, we commend the NRC Board on Agriculture for undertaking this effort. To assess the economic, environmental, technical, social, and policy character of American agriculture operating across a wide spectrum of ecosystems with over 2 million individual operators is, indeed, a Herculean task. Differences in philosophy between alternative and conventional agricultural proponents cannot be fully resolved by scientific analysis. Only long-term comparisons of whole farm systems based on scientific evidence can be subjected to such scrutiny. The state of science on alternative agriculture is not at the point of supporting major policy changes. We view the board's Alternative Agriculture report, therefore, as a challenge to researchers, producers, and policymakers to fine tune the current research-based agricultural systems and not as a blueprint from which the complex and diverse U.S. agricultural enterprise should be modeled. Many of the concepts, practices, and recommendations endorsed within the report provide common ground upon which to build both conventional and alternative agriculture. The report has already proved its value by providing the catalyst for establishing dialog among a wide spectrum of agriculturalists, scientists, and policymakers.

We are not here to defend the status quo, but to support the common goal of undergirding U.S. agriculture with the technologies and infrastructure such that all resources are utilized with maximum efficiency and environmental capability while being economically viable. Such an agricultural system in our opinion should be sustainable.

While today's technology provides for the option of chemically dependent crop monocultures, the land-grant university system and Federal research establishment have literally a century's worth of data and experimental evidence clearly demonstrating the benefits of system diversity, rotations, and the benefits of legumes and manures. We stand solidly behind today's science-based agricultural recommendations which include many of those components of crop and animal husbandry espoused in the Alternative Agriculture report.

We agree with the primary message in the NRC report, that is, to maximize the efficiency of resource investments in the production system, including the full utilization of onfarm resources. This is consistent with the land-grant university and USDA position.

Technology, however, is not available to sustain today's food demands with total reliance on organic or onfarm resource production systems. Any differences with those who espouse a more diverse and more onfarm resource dependent agriculture are not so much about the scientific principles upon which more self-reliant systems are based, but what American agriculture has become due to economic forces, including farm policies and lifestyle choices. Advances in and application of land saving, biological, and chemical technology has been driven primarily by rising prices or scarcity of land often reinforced by government programs. Advances in and application of mechanical and other labor saving technology has been driven by rising wage rates in the American economy.

In summary, the alternative agricultural agenda should be viewed at present primarily as a research agenda and not as a package of available technology. We are in general agreement that technology option needs need to be broadened in order to cope with future resource and environmental concerns.

Furthermore, we must not forget that our current agricultural system has not only sustained production output, but enhanced this output at the annual rate of 1 to 2 percent. Thus, we must take into account that any alternative system must be measured against this standard or add land resources if future needs cannot be met by sustained production with less than 1-percent growth.

Society has progressed by fine tuning its experience and building upon a solid research foundation in correcting unforeseen consequences of previous actions. The NRC report should be viewed as a critique for adjusting where necessary an agricultural system that has, indeed, served us well. Because this system has been forged from a long history of solid research, it has withstood all manner of stresses, including environmental as well as fluctuating economic conditions. Clearly the Alternative Agriculture report raises several major issues that must be addressed, but we do not believe the knowledge is available to move toward major policy shifts without further research. As the report itself maintains, conventional and alternative systems may use many common practices or methods, but they usually differ in overall philosophy. Policy decisions should not be based on philosophy without a sound knowledge base or experience to back it up. Research agendas are dictated by funding. Here is where the report can serve its most important function by contributing to the forging of the national research agenda.

Mr. Chairman, we again thank you for this opportunity to make our formal statement, and will stand by for further questions.

[The prepared statement of representatives from the Council for Agricultural Science and Technology, together with the report entitled "Alternative Agriculture, Scientists' Review," follow:]

PREPARED STATEMENT FROM REPRESENTATIVES FROM

THE COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

DR. VIRGIL W. HAYS
Animal Science Department
UNIVERSITY OF KENTUCKY

DR. VERNON W. RUTTAN
Department of Agricultural and Applied Economics
UNIVERSITY OF MINNESOTA

DR. FRED P. MILLER
Department of Agronomy
THE OHIO STATE UNIVERSITY

TESTIMONY BEFORE JOINT ECONOMIC COMMITTEE

JUNE 6, 1990

STATEMENT FROM REPRESENTATIVES FROM THE COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

- PREFACE -

We are pleased to have the opportunity to appear before this Committee to respond to the National Research Council report *Alternative Agriculture*. We respectfully request that our proposed statement and the CAST review of the NRC report be entered into the record.

The Council for Agricultural Science and Technology (CAST) was requested to "undertake a review of the methodology and findings of the recently published National Research Council study, *Alternative Agriculture*." The request for the CAST document was made in a letter from Lee H. Hamilton, Chairman of the Congress of the United States-Joint Economic Committee to CAST President, Dr. Virgil Hays. "In particular the report, *Diet, Nutrition and Cancer*, prepared by CAST in 1982 is the type of study we would hope to see in this case." This statement indicates that the Joint Economic Committee desires a compilation of individual reviews by scientists rather than a consensus task force report prepared by joint authorship. In his letter, Congressman Hamilton further stated, "With a large enough panel of CAST members I am certain that we would receive a comprehensive review."

In response to the request, Dr. Lowell S. Jordan, president-elect of CAST, assumed chairmanship of the project and contacted over 50 agricultural and food scientists and specialists throughout the United States; most are members of the CAST Board of Directors. In a letter to the participants, Dr. Jordan stated, "Our purpose is to provide you the opportunity to respond as an agricultural scientist to the request [from Congressman Hamilton]." "Your critique will be published as submitted." In response, 44 scientists and specialists reviewed the National Research Council (NRC) report and contributed 41 reviews to this document. This document is the result of the coordinated effort by these experts from various agricultural disciplines and specialties.

CAST followed its long-established policy of selecting credentialed and highly qualified specialists to make this response, including those who are not members of CAST. For non-members who prepared responses, CAST does provide a one year complementary membership when each project and report are completed. No financial remuneration is paid to any authors except where expenses for travel might be involved.

The purpose of this CAST report is: (1) to present the individual scientists' reviews of the *Alternative Agriculture* report, and (2) to compare the opinions of the reviewers with statements concerning the same subject in the NRC report. The document is divided into four parts: highlights, executive summary, summary, and scientists' reviews.

The reviewers comments were not changed by CAST, except for agreed on minor editorial changes. All statements made in each individual review reflect the viewpoints of the author. The opinions in this document do not represent those of CAST, its officers, the member scientific societies, or any public or private institutions associated with either CAST or the reviewers.

- REVIEW -

At the outset, we commend the NRC Board on Agriculture for undertaking this effort. To assess the economic, environmental, technical, social, and policy character of American agriculture operating across a wide spectrum of ecosystems with over two million individual operators is a herculean task. Differences in philosophy between alternative and conventional agricultural proponents cannot be fully resolved by scientific analysis. Only long-term comparisons of whole farm systems based on scientific evidence can be subjected to such scrutiny. Such data are not available, particularly for alternative systems. We view the Board's *Alternative Agriculture* report, therefore, as a challenge to researchers, producers, and policy makers to fine-tune the current research-based agricultural systems and not as a blueprint from which the complex and diverse U.S. agricultural enterprise should be modeled. Many of the concepts, practices, and recommendations endorsed within the NRC report provide common ground upon which both conventional and alternative agriculture can build.

Since its origins, humankind has been inexorably linked with agriculture of some type for its sustenance. In its earliest and most primitive form, agriculture consisted of a hunting and gathering system. Land, its natural bounty, and the labor of the forager were the only resource requirements. This system required hundreds of acres to sustain a person. Subsequent advances in crop and animal husbandry allowed for a more reliable and sustained food supply. From this historical fabric, large segments of populations were relieved from agriculture to develop goods and services contributing to the advancement of civilization. Within the last century, science has been applied to agriculture. One of the benefits of today's agriculture is that only a very small percentage of the population are required to produce the food needs for the rest of us. Furthermore, today's land requirements for agriculture have been reduced by at least two orders of magnitude compared to the land required to sustain populations relying on hunting and gathering systems. For the United States, this ratio is about 1.7 acres of cropland per capita compared to about 0.6 to 0.7 acres per capita on a global scale.

Concerns are being raised by some about today's agriculture. They range from environmental impacts caused by erosion and water quality deterioration to trace amounts of actual and potential chemical residues in foods. There are social, economic, and policy concerns as well. *Alternative Agriculture* is an excellent review of these concerns. As the report emphasized, there are those who are looking for and implementing alternative agricultural production systems as compared to today's most commonly used technologies.

We have attempted to ask several questions. After decades of developing today's science-based agriculture through rigorous testing protocols, where are the short-falls and unforeseen impacts? And for those challenging this system or seeking alternative systems, where is the common ground for building a viable and sustainable agriculture? We believe there is much common ground.

It is important to review several basic tenets that are applicable to any crop and animal husbandry system.

- Humankind's energy source is the sun with plants as the energy converter.
- Humankind's sustenance and well-being, including the population to be supported, are dependent upon the stocks of nutrients and flow of energy through the biological system.
- Only a small fraction of the earth's biota is consumed for human food and only a relatively small portion of the earth's land area is arable.

- Other than hunting-gathering systems, plants and animals must be selected and grown in areas and systems where they are not native or in communities that are less diverse than the natural ecosystem which was displaced for their production.

- Managing ecosystems to accommodate crop and animal production of any kind results in changing the original ecosystem and environmental disturbance.

- As a result of the preceding tenet, pest and weed control and nutrient management are the foremost management requirements for most systems.

- All ecosystems leak, i.e., some mineral and organic matter are removed from the area; disturbing an ecosystem usually results in changes in the hydrology of the system which often increases these leakages.

- Harvesting agricultural products from the land on which they were produced without replenishing (recycling) the nutrient base will reduce the productivity of the land.

- The amount of food production, therefore, is a function of labor/management plus resource/energy inputs.

The latter tenet or formula is the "law" which governs the entire spectrum of any agricultural production system. A primitive foraging system relies totally on the labor of the gatherer-hunter. No other resources are invested in the system except for the land requirement which is huge. At the other extreme of this spectrum are those low diversity systems such as hydroponics or chemically-dependent crop monocultures where labor and even management are minimized and replaced by resource and energy inputs "managed" in part by computer programs.

Our position is that most of U.S. agriculture is operating closer to the middle of these extremes than at either end. While today's technology provides for the option of chemically-dependent crop monocultures, the land-grant university system and federal research establishment have literally a century's-worth of data and experimental evidence clearly demonstrating the benefits of system diversity, rotations, and the benefits of legumes and manures. We stand solidly behind today's science-based agricultural recommendations which include many of those components of crop and animal husbandry espoused in *Alternative Agriculture*.

We agree with the primary message in the NRC report, i.e., maximize the efficiency of resource investments in the production system, including the full utilization of on-farm resources. This is consistent with the land-grant university and USDA, ARS position. We agree with the report authors that agriculture cannot be sustained under today's food demands with total reliance on organic or on-farm resource production systems.

We believe the conflict among us and those who espouse a more diverse and more on-farm-resource-dependent agriculture is not so much a difference about the scientific principles upon which more self-reliant systems are based, but what American agriculture has become due to economic forces, including farm policies, and life-style choices that have modified what is known to be sound agricultural husbandry. Advances in and application of land saving, biological, and chemical technology, has been driven primarily by rising prices or scarcity of land - often reinforced by government programs. Advances in and application of mechanical and other labor-saving technology has been driven by rising wage rates in the American economy. Quite frankly, some of today's technologies allow farmers to be sloppy managers and still get by. A major question needing clarification is whether today's agricultural technology options are resulting in environmental impacts because of poor management or whether the technologies themselves are predisposed to environmental insults or both.

Some technologies are used to produce monocultures and low diversity systems suited to take advantage of government programs and to provide opportunities for off-farm employment. When over half of the U.S. farm population generates significant amounts of their income from off-farm sources, we need to determine whether this is a life-style choice to increase their income or a necessity due to unprofitable production technologies. As more management is required for alternative systems, the amount of income may not be adequate to satisfy those who choose an easy-to-manage monoculture so they have the opportunity for other income.

One of the short-comings of *Alternative Agriculture* is that it tends to bifurcate the broad agricultural production system spectrum into a simple two category taxonomy, namely conventional and alternative agriculture. Conventional or traditional agriculture was never defined other than through the inference that it was more dependent upon chemical pest control, commercial fertilizers, and tended toward less diversity than alternative agriculture. But there are dangers in such simple taxonomic classes. Good managers of traditional systems utilize most of the practices and technologies ascribed to alternative agriculture. There is no evidence that well managed traditional production systems based on researched recommendations have any greater impact on the environment than alternative systems or that the quality of the food supply generated from such systems is less wholesome than that generated from alternative systems. We reject the notion that the NRC report implies, as some media and others have concluded, alternative agriculture is available and superior to conventional systems. This premise is not documented.

Following are several points selected from the report that need emphasis, clarification or that we take exception to:

- We all have the same goal: a secure, reliable, high quality, and affordable food supply that is produced in an environmentally benign manner and is socially acceptable and economically viable for the producer.

- The NRC report is not meant to be a scientific treatise from which policies should be reformed to apply alternative technologies across the broad ecological spectrum of U.S. farmland without an adequate research base.

- The case studies should be viewed as samples within the whole and not of the whole. These cases should have included failures (from which we can learn) as well as comparisons to counterpart conventional systems under various levels of management. No environmental impact data were available from these studies. No follow-up comparisons were made.

- The economic advantage of several case studies resulted from premium prices in niche markets. The NRC report did not indicate whether the incentive to exploit these markets was economically-driven or philosophically-driven.

- Pest control strategies including IPM, rotations, and biological control are important but may fall short of necessary pest control, especially for certain crops and ecosystems. Chemical pest control should remain as one of the weapons in the total arsenal of pest control strategies.

- One of the major incentives for using commercial fertilizers is being able to order precisely the nutrient analysis needed in minimal volume at the time wanted and applied (e.g. broadcast, banded, split, injected, etc.), with relative ease and as compared to manures and sludges which are bulky, unpleasant to handle and accumulate over time with only narrow windows of application. Furthermore, manures and sludges are not without their own unique environmental threats, including the potential for coliform contamination of water, biochemical oxygen demand loading of surface waters if washed off, nitrate leaching (some of the highest nitrate contaminated areas are under heavy manure and legume operations), nutrient imbalances such as phosphorus, potassium and sodium, and heavy metal contamination of soil in the case of sludges. Pesticides provide similar trade-offs such as time-management, ease of application, and less risk of weeds getting out-of-control when weather shuts down cultivation options.

- The NRC report emphasizes the negative side of pesticides (plant and animal), without considering trade-offs.
- Legume nitrogen is not necessarily available at the optimum time and may be unavailable in stress (e.g., wet or dry) years. Other nutrients are necessary to compliment legume nitrogen.
- Under any analysis of U.S. plant nutrition requirements, utilizing all practically and economically available on-farm and nearby organic nutrient sources, commercial fertilizers will remain a major component of U.S. nutrient management strategy. Good management will utilize all sources and match the commercial source to fit the remaining nutrient needs.
- The NRC report states that the alternative animal agriculture systems characterized by less confinement, greater use of pasture, lower incidence of disease and consequently less use of antibiotics are more productive and more profitable. It further implies that veterinarians, universities, drug companies and regulatory agencies encourage the substitution of drugs for sound management and environmental practices. The recommendations of livestock extension specialists, health programs of practicing and extension veterinarians, residue avoidance programs of livestock and poulty producer groups, residue monitoring programs of regulatory agencies, production and business records of livestock and poultry producers and the university and industry research data do not support this contention.
- Increasing forages and other crops to rotations implies additional land requirements and markets to absorb the increased livestock and forages. The environmental trade-offs (e.g., erosion) of this option were not addressed.
- It is implied by the NRC report and assumed by the public and media that naturally produced food is more wholesome with less risk of deleterious health affects. Such data are not available for comparison under alternative systems. Naturally-occurring toxins and metabolites are not without risk; thus, one cannot assume that reducing or eliminating synthetic chemicals from production systems reduces risk. Breeding for resistance to pests is, likewise, not without risk in increasing metabolites that may be more toxic to humans than the parent germplasm or synthetic pesticide being replaced. The NRC report speaks to harmful residues without mentioning that modern analytical technologies permit detection of levels that are biologically insignificant.
- Depending how far one goes in reducing or eliminating production options in the form of pesticides, commercial fertilizers, and animal management systems, food supply reductions can occur with resulting increased food costs.
- For certain crops and ecosystems, monocultures (e.g., citrus, orchard crops) are the only option.
- One can argue that agricultural research has been reductionist, i.e., looking at the parts rather than the whole. American farmers have been very successful at integrating this research into their own production system. Whole farm research is a worthy goal, but not without significant ramifications. First, such research is very expensive and long-term. Second, this type of research is extremely complex and, unless executed in a comprehensive experimental design, runs the risk of overlooking critical interactions of individual components that may dampen a net positive result. Thus, such whole farm research should actually be broadened to include the local economy and social structure since off-farm employment options may override the advantage of a well integrated alternative production unit.

- Biotechnology, while holding much promise for the future of agriculture, is nowhere near providing replacement options for pesticides.

In summary, the primary message in this NRC report is the reduction in use of synthetic chemicals and fertilizers through increased efficiencies and utilization of on-farm resources with intensified management using options such as IPM, rotations, legumes, recycling manures, etc. There is a bias toward the biological approach versus the more simplifying approach offered by chemistry and engineering. The alternative agriculture agenda should be viewed at present primarily as a research agenda and not as a package of technology. We are in general agreement that technology options needs to be broadened in order to cope with future resource and environmental concerns.

It is our position that, while improvements in agricultural systems can and should be made, most conventional practices have a sound research base and should be refined and adjusted as necessary through research on these and alternative systems. We argue that many well managed conventional production systems are economically viable and sustainable. IPM, pest resistant variety selection, nutrient management through soil testing, nutrient banding, split applications, reduced tillage, residue management, rotations, cultural practices such as timely planting to reduce pests, and other management strategies are commonly used in conventional systems. Insecticide rates have been declining for a decade and a half. Farmers must operate within the constraints of government policies and programs, economic and social systems to remain viable. Furthermore, we must not forget that our current agricultural system has not only sustained production output but enhanced this output at the annual rate of 1 to 2 percent. Thus, we must take into account that any alternative system must be measured against this standard or add land resources if future needs cannot be met by sustained production with less than one percent growth.

Society has progressed by fine-tuning its experience and building upon a solid research foundation and correcting unforeseen consequences of previous actions. The NRC report should be viewed as a critique for adjusting, where necessary, an agricultural system that has served us and large segments of the world population well. Because this system has been forged from a long history of solid research, it has withstood all manner of stresses, including environmental as well as fluctuating economic conditions. Clearly, the *Alternative Agriculture* report raises several major issues that must be addressed. But we do not believe the database is available to move toward major policy shifts without further research. As the NRC report itself maintains, "conventional and alternative systems may use many common practices or methods, but they usually differ in overall philosophy." Policy decisions should not be made based on philosophy without a sound database or experience to back it up. Research agendas are dictated by funding. Here is where the NRC report can serve its most important function by contributing to the forging of a national research agenda.

Alternative Agriculture
Scientists' Review

Special Publication
No. 16 July 1990

Council for Agricultural Science and Technology
Ames, Iowa

The Council for Agricultural Science and Technology (CAST) is a nonprofit organization comprised of 29 member scientific societies and many individual, company, nonprofit, and associate society members. The 56 member board of directors is composed of 48 representatives of the scientific societies and individual members, and an executive committee. CAST provides scientific information on key national issues in food and agriculture to policymakers, the news media, and the public. As an educational organization, CAST takes no advocacy positions on issues.

Through representatives on the CAST Board of Directors, the member societies are responsible for the policies and procedures followed in developing, processing, and disseminating the documents produced. Depending on the nature of the publication, the society representatives nominate qualified persons from their respective disciplines for participation in the preparation. Aside from these involvements, the member societies have no responsibility for the content of any CAST publication.

Special publications consist of two or more documents, each with one or more authors; nonexpository subject matter; or scientists' testimony on issues concerning food and agriculture. The authors named in each section of this report are responsible for the contents. They served as independent scientists, not as representatives of their employers, and received no honoraria. CAST publishes and distributes the documents.

All CAST documents may be freely reproduced in their entirety for independent distribution. If this document is reproduced, credit to the authors and CAST would be appreciated. CAST bears no responsibility for the use that may be made of its publications, nor does CAST endorse products or services mentioned therein.

Membership

Member Societies

American Academy of Veterinary and Comparative Toxicology
American Association of Cereal Chemists
American Dairy Science Association
American Forage and Grassland Council
American Meat Science Association
American Meteorological Society
American Peanut Research and Education Society
American Phytopathological Society
American Society for Horticultural Science
American Society of Agricultural Engineers
American Society of Agronomy
American Society of Animal Science
American Veterinary Medical Association
Aquatic Plant Management Society
Association of Official Seed Analysts
Council on Soil Testing and Plant Analysis
Crop Science Society of America
Institute of Food Technologists
International Society of Regulatory Toxicology and Pharmacology
North Central Weed Science Society
Northeastern Weed Science Society
Plant Growth Regulator Society of America
Poultry Science Association
Rural Sociological Society
Society of Nematologists
Soil Science Society of America
Southern Weed Science Society
Weed Science Society of America
Western Society of Weed Science

Associate Societies

Individual Members

Sustaining Members
Companies and Cooperatives
Nonprofit Associations

Library of Congress Cataloging-in-Publication Data

Alternative agriculture: scientists' review.
p.   cm. — (Special publication / Council for Agricultural Science and Technology ; 16 (July 1990))
Includes bibliographical references (p.   ).
1. Alternative agriculture. 2. Alternative agriculture—United States. 3. Agricultural systems—United States. I. Council for Agricultural Science and Technology. II. Series: Special publication (Council for Agricultural Science and Technology) ; no. 16.
S494.5.A65A4333 1990
630—dc20   90-1813
ISSN 0194-407X   CIP

Cover design by Lynn Ekblad, Chichaqua Bend Studios, Ames, Iowa. Cover photograph used with permission of National Academy Press, Washington, D.C.

Contributing Authors

Lowell S. Jordan, Chair, Department of Botany and Plant Sciences, University of California, Riverside

John R. Abernathy, Texas Agricultural Experiment Station, Texas A&M University, Lubbock

Samuel R. Aldrich, Soil Fertility Extension, University of Illinois at Urbana-Champaign

Charles A. Black, Department of Agronomy, Iowa State University, Ames

Richard E. Bradley, College of Veterinary Medicine, University of Florida, Gainesville

Harold O. Carter, Agricultural Issues Center, University of California, Davis

Robert M. Devlin, Cranberry Experiment Station, University of Massachusetts at Amherst

Don W. Dickson, Department of Entomology and Nematology, University of Florida, Gainesville

Michael D. Duffy, Department of Economics, Iowa State University, Ames

Donald N. Duvick (retired), Pioneer Hi-Bred International, Inc., Des Moines, Iowa

Richard S. Fawcett, Fawcett Consulting, Huxley, Iowa

Cornelia B. Flora, Department of Sociology, Virginia Polytechnic Institute and State University, Blacksburg

Ralph W. Fogleman, Upper Black Eddy, Pennsylvania

Leonard P. Gianessi, Resources for the Future, Inc., Washington, D.C.

Joseph F. Guenthner, Department of Agricultural Economics and Rural Sociology, University of Idaho, Moscow

Richard R. Hahn, Kansas Agricultural Value-Added Center, Kansas State University, Manhattan

Virgil W. Hays, Department of Animal Sciences, University of Kentucky, Lexington

Glenn A. Helmers, Department of Agricultural Economics, University of Nebraska, Lincoln

William D. Hohenboken, Department of Animal Science, Virginia Polytechnic Institute and State University, Blacksburg

Barry J. Jacobsen, Department of Plant Pathology, Auburn University, Auburn, Alabama

James L. Jordan, Department of Botany and Plant Sciences, University of California, Riverside

Thomas H. Jukes, Department of Biophysics, University of California, Berkeley

Patricia A. Kendall, Department of Food Science and Human Nutrition, Colorado State University, Fort Collins

Ellery L. Knake, Department of Agronomy, University of Illinois at Urbana-Champaign

Robert C. Lanphier, III, AGMED Inc., Springfield, Illinois

Gary A. Lee, Idaho Agricultural Experiment Station, University of Idaho, Moscow

J. E. Legates, Department of Animal Science, North Carolina State University, Raleigh

Gordon C. Marten, USDA, Agricultural Research Service, Beltsville, Maryland

John F. Marten, Staff Economist, *Farm Journal*, West Layfette, Indiana

Fred P. Miller, Department of Agronomy, The Ohio State University, Columbus

Gary D. Osweiler, Veterinary Diagnostic Laboratory, College of Veterinary Medicine, Iowa State University, Ames

Arnold A. Paulsen, Department of Economics, Iowa State University, Ames

Alternative Agriculture: Scientists' Review

Don C. Peters, Department of Entomology, Oklahoma State University, Stillwater

Leon H. Russell, Department of Veterinary Public Health, College of Veterinary Medicine, Texas A&M University, College Station

Clinton B. Reeder, Pendleton, Oregon

Vernon W. Ruttan, Department of Economics, University of Minnesota, St. Paul

M. Scott Smith, Department of Agronomy, University of Kentucky, Lexington

Deon D. Stuthman, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul

Robert D. Sweet, Vegetable Crops Department, Cornell University, Ithaca, New York

Allen H. Trenkle, Department of Animal Science, Iowa State University, Ames

Luther G. Tweeten, Department of Agricultural Economics, The Ohio State University, Columbus

John N. Walker, Department of Agricultural Engineering, University of Kentucky, Lexington

Maurice E. Watson, Research-Extension Analytical Laboratory, The Ohio State University, Wooster

Philip Westra, Department of Plant Pathology and Weed Science, Colorado State University, Fort Collins

Karen K. Wilken, Department of Food Science and Human Nutrition, Colorado State University, Fort Collins

Dean R. Zimmerman, Department of Animal Science, Iowa State University, Ames

Foreword

The Council for Agricultural Science and Technology (CAST) was requested to "undertake a review of the methodology and findings of the recently published National Research Council study, *Alternative Agriculture*." The request for the CAST document was made in a letter from Lee H. Hamilton, Chairman of the Congress of the United States-Joint Economic Committee to CAST president, Dr. Virgil Hays. "In particular the report, *Diet, Nutrition and Cancer*, prepared by CAST in 1982 is the type of study we would hope to see in this case." This statement indicates that the Joint Economic Committee desires a compilation of individual reviews by scientists rather than a consensus task force report prepared by joint authorship. In his letter, Congressman Hamilton further stated, "With a large enough panel of CAST members I am certain that we would receive a comprehensive review."

In response to the request, Dr. Lowell S. Jordan, president-elect of CAST, assumed chairmanship of the project and contacted over 50 agricultural and food scientists throughout the United States; most are members of the CAST Board of Directors. In a letter to the participants, Dr. Jordan stated, "Our purpose is to provide you the opportunity to respond as an agricultural scientist to the request [from Congressman Hamilton]." "Your critique will be published as submitted." In response, 44 scientists and specialists reviewed the National Research Council (NRC) report and contributed 41 reviews to this document. The following document is the result of the coordinated effort by these experts from various agricultural disciplines and specialties.

We especially thank Dr. Jordan for assuming leadership and responsibility for this project. His painstaking dedication to this comprehensive task was truly exceptional. He and Dr. James L. Jordan devoted a great deal of personal time condensing the review articles and writing the summaries; their expertise is reflected in these sections.

The purpose of this CAST report is: (1) to present the individual scientists' reviews of the *Alternative Agriculture* report, and (2) to compare the opinions of the reviewers with statements concerning the same subject in the NRC report. The document is divided into four parts: highlights, executive summary, summary, and scientists' reviews.

The reviewers comments were not changed by CAST, except for agreed on minor editorial changes. All statements made in each individual review reflect the viewpoints of the author. The opinions in this document do not represent those of CAST, its officers, the member scientific societies, or any public or private institutions associated with either CAST or the reviewers.

As Drs. Lowell S. Jordan and James L. Jordan point out, one of the problems identified early in the project was the difficulty in differentiating between alternative and conventional agriculture. The lack of clarity in the definitions of the two systems is illustrated by a statement made on page 425 of the NRC report. The statement reads, "Conventional and alternative systems may use common practices or methods, but they usually differ in overall philosophy." The purpose of CAST is to evaluate scientific information, not philosophical issues. Therefore, this document will not discuss the philosophical differences between alternative and conventional agriculture. It will address the issues related to the scientific aspects of *Alternative Agriculture*.

The reader is strongly advised to read both the NRC report and the comments by the reviewers. The subject, alternative agriculture, involves all realms of agriculture, and is far too complex to cover exhaustively in either this document or the NRC report.

On behalf of CAST, we thank the participants, who gave of their time and talents to prepare this document as a contribution of the scientific community to public understanding. We thank the employers of the participants, who made their time available at no cost to CAST. The members of CAST deserve special recognition because the unrestricted contributions they have made in support of the work of CAST have financed the preparation of this special publication.

This publication is being distributed to the Joint Economic Committee; certain members of Congress, the National Academy of Sciences, the National Research Council, the Food and Drug Administration, the Environmental Protection Agency, the U.S. Department of Agriculture, the Office of Technology Assessment, the Office of Management and Budget; to media personnel who have asked to receive CAST publications; and to institutional members of CAST. Individual members may receive a copy upon request. The publication may be published or reproduced in its entirety without permission. If copied in any manner, credit to the authors and CAST should be given.

Stanley P. Wilson
Executive Vice President

Kayleen A. Niyo
Scientific Editor

James L. Oblinger
President

Contents

Abbreviations x

1 **Highlights** . . . . CAST 1

2 **Executive Summary** . . . . Lowell S. Jordan 4

3 **Summary** . . . . Lowell S. Jordan and James L. Jordan 6

SCIENTISTS' REVIEWS

4 Agricultural Engineering, Food Science, and Toxicology

Alternative Agriculture . . . . Ralph W. Fogleman 23
Review of *Alternative Agriculture* . . . . Richard R. Hahn 26
Comments on *Alternative Agriculture* . . . . . Thomas H. Jukes 28
Commentary on the National Research Council Publication, *Alternative Agriculture* . . . . Robert C. Lanphier III 33
Review of *Alternative Agriculture* . . . . Gary D. Osweiler 35
Comments on the National Research Council Study, *Alternative Agriculture* . . . . John N. Walker 36
Alternative Agriculture: Its Potential Impact on Nutrition and Health . . . . Karen K. Wilken and Patricia A. Kendall 39

5 Animal Sciences

Alternative Agriculture: Twentieth Century (Limited) . . . . Richard E. Bradley 42
Review Comments on Chapters 1, 2, and 4 . . . . Virgil W. Hays 43
Alternative Agriculture: An Animal Scientist's Perspective . . . . William D. Hohenboken 50
Comments on the National Research Council Publication, *Alternative Agriculture* . . . . J. E. Legates 54
Comments on *Alternative Agriculture* . . . . . . Leon H. Russell 56
Some Comments Relative to Animal Agriculture in a Critique of *Alternative Agriculture* . . . . Allen H. Trenkle 59
Comments on *Alternative Agriculture* . . . Dean R. Zimmerman 62

Alternative Agriculture: Scientists' Review

6 Crop and Soil Sciences

Alternative Agriculture: A Timely, But Flawed Report . . . . Samuel R. Aldrich 66
The *Alternative Agriculture* Report . . . . Charles A. Black 68
Alternative Agriculture and Related Myths . . Donald N. Duvick 78
Research Needs and Achievements Identified in the NRC Report Entitled *Alternative Agriculture* are on Target . . Gordon C. Marten 82
Comments on *Alternative Agriculture* . . . . Fred P. Miller 83
Comments on *Alternative Agriculture* . . . . M. Scott Smith 88
Alternative Agriculture: A Concept We Cannot Ignore . . . . Deon D. Stuthman 90
Alternative Agriculture: Have We Been There Before? . . . . Maurice E. Watson 92

7 Economics and Sociology

The Three R's of Agricultural Sustainability: Reality, Redirection, and Restraints . . . . Harold O. Carter 96
Comments on *Alternative Agriculture* . . . . . Michael D. Duffy 99
Alternative Agriculture . . . . Cornelia B. Flora 102
Comments on *Alternative Agriculture* . . . Leonard P. Gianessi 105
Comments on *Alternative Agriculture*: A Report Prepared by the National Research Council . . . . John F. Marten 111
Alternative Agriculture: Policy Might Induce Rapid Adoption . . . . Arnold A. Paulsen 120
Book Review: *Alternative Agriculture* . . . . . Clinton B. Reeder 122
Alternative Agriculture: Sustainability is Not Enough . . . . Vernon W. Ruttan 130
Comment on *Alternative Agriculture* Systems . . . . Luther G. Tweeten and Glenn A. Helmers 134

8 Plant Protection

Alternative Agriculture: Whose Perspective . . . . John R. Abernathy 139
Alternative Agriculture: Proceed with Caution . . . . Robert M. Devlin 141
Comments on *Alternative Agriculture* . . . . . . Don W. Dickson 142
Comments on *Alternative Agriculture* . . . . Richard S. Fawcett 145
Alternative Agriculture: A Plant Pathologist's Review . . . . Barry J. Jacobsen 150
Review of *Alternative Agriculture* . . . . Ellery L. Knake 153
Alternative Agriculture: Application to Potato Production . . . . Gary A. Lee and Joseph F. Guenthner 163
A Response To the NRC Committee Report on Alternative Agriculture . . . . Don C. Peters 170
Alternative Agriculture: Seriously Flawed . . . Robert D. Sweet 173
LISA: Where Do Weed Scientists Fit In? . . . . . . Philip Westra 177

Abbreviations

ASCS	Agricultural Stabilization and Conservation Service
CAST	Council for Agricultural Science and Technology
CRP	Conservation Reserve Program
EPA	Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
IOM	Institute of Medicine
IPM	Integrated Pest Management
K	Potassium
LISA	Low Input Sustainable Agriculture
N	Nitrogen
NAS	National Academy of Sciences
NRC	National Research Council
P	Phosphorus
SCS	Soil Conservation Service
USDA	U.S. Department of Agriculture

1

Alternative Agriculture Scientists' Review Highlights

There is no widely accepted definition of alternative agriculture; likewise conventional agriculture is not well defined. There is considerable overlap in perceptions of what these terms mean. However, it is obvious that well managed conventional farms will qualify for inclusion under alternative agriculture. The major points of issue are philosophy and management.

There are those who will interpret the findings of the National Research Council (NRC) report, *Alternative Agriculture*, to be advocating organic farming. That is not the case. The definition of alternative agriculture on page 27 of the NRC report does not mention the term.

Alternative Agriculture focused upon a relatively small number of sites and circumstances. These need to be interpreted as selected examples rather than random samples. They do not represent scientific comparisons, but do clearly indicate that under certain specific conditions the management schemes utilized can be effective.

The section of *Alternative Agriculture* entitled The Power of Policy is justifiably critical of federal farm programs as discouraging the adoption of alternative agriculture practices. In other words, while there is no question that high target prices in the past have encouraged the use of yield-maximizing production practices on eligible acreage, it is incorrect to state that farm programs are responsible for surplus production. To the contrary, they have limited excess productive capacity. But by doing so through acreage limitations "traded off" for deficiency payments, farmers' alternatives have, in some cases, been limited. Also, recent policy changes have substituted county average yields for individual farm yields, therefore, negating the effect of high farm yields on deficiency payments.

Some read *Alternative Agriculture* to suggest that agriculture is the major culprit in environmental problems. This is not true. The vast majority of farmers are very concerned about the environment and also are very concerned about the present and future productivity of the land. In some instances where environmental damage is scientifically documented, directed changes toward protecting the environment and concurrently maintaining a viable and profitable agricultural industry are in the best interests of society. Ideally, the driving force for change in American agriculture will be well documented scientific evidence. More research is needed to systematically measure the environmental impact of a variety of practices, both on experiment stations and on farmers' fields.

Alternative Agriculture strongly supports Integrated Pest Management (IPM), rotation of crops, and biological control as ways of reducing, and in some cases, eliminating chemicals in agricultural production. These concepts are important, but may fall short in providing total answers for serious agricultural pest and pathogen problems. IPM has been widely used and with most success in control of insects. Crop rotation is effective with many pests but ineffective with some, and, after more than 30 years of research, there are only a few success stories for biological control. The most successful pest management systems of the future will use IPM concepts that involve crop rotations, utilize host plant resistance where appropriate, and use cultural and biological controls to the maximum along with judicious use of chemicals.

Alternative Agriculture recommends greatly increased use of animal wastes and green manure crops to supply needed nutrients for crops. However, it is very difficult to control the amount and timing of nutrients supplied to crops by these methods. Animal wastes may add significantly to pollution problems, and widespread use of green manure crops to provide nutrients will require additional crop land to maintain present levels of production. Where feasible, increased use of properly applied animal wastes and green manure crops can be productive; however, synthetic fertilizers have provided a foundation for crop production in America and on-farm inputs can substitute for only a portion. All plant nutrients should be judiciously applied with efficiency of production rather than maximum production as the goal.

Alternative Agriculture acknowledges that judicious chemical usage must be incorporated into many sustainable systems of agriculture to meet the needs and demands of our largely urban population in the United States and many other developed countries. Nowhere in the NRC report does the committee advocate total removal of pesticides or synthetic fertilizers.

Alternative Agriculture neither documents by research nor demonstrates by recorded field experience the economic viability of an agriculture that adheres to the alternative system. The extensive coverage and dependence on case studies reflects the paucity of solid factual information regarding the economic benefits of the alternative system. This renders certain findings and related recommendations more philosophic than scientific.

Alternative Agriculture recommends agricultural practices that may significantly reduce food supplies, thus placing a severe financial burden upon low income consumers and intensifying world food shortages. Also, higher food prices have nutritional ramifications that are especially acute among the poor. Unfortunately, the NRC report provides little information as to how alternative agricultural practices would affect food prices.

Both the writers of *Alternative Agriculture* and the reviewers appreciate the need for sensitivity of agriculture to documented problems and the desirability of being willing to change in ways consistent with solutions to those problems. Concurrently, those desiring change have an obligation to appreciate the need for maintaining efficiency and profitability as agriculture evolves. Scientists, extension educators, agribusiness personnel, and dedicated producers can modify present agricultural systems to satisfy production, environmental, and food safety requirements.

Society has progressed by fine-tuning its experience and building upon a solid research foundation and correcting unforeseen consequences of previous actions. The NRC report, *Alternative Agriculture*, should be viewed as a critique for adjusting, where necessary, an agricultural system that has served us well. Because this system has been forged from a long history of solid research, it has withstood all manner of stresses, including environmental as well as fluctuating economic conditions. Clearly the report, *Alternative Agriculture*, raises several major issues that must be addressed. But we do not believe the knowledge is available to move toward major policy shifts without further research. As the NRC report itself maintains, "conventional and alternative systems may use many common practices or methods, but they usually differ in overall philosophy." Policy decisions should not be made based on philosophy without a sound knowledge base or experience to back it up. Research agendas are dictated by funding. Here is where the report, *Alternative Agriculture*, can serve its most important function by contributing to the forging of a national research agenda.

2

Executive Summary

The report, *Alternative Agriculture*, by the National Academy of Sciences-National Research Council (1989), addresses systems for environmentally sound and economically viable agricultural production emphasizing minimal external inputs and diversification. The report indicates that there are two primary sets of agricultural systems, conventional and alternative. The alternative spectrum of farming systems, being discussed as available and superior to conventional agriculture, is neither well defined nor supported by adequate, current, scientifically based information. Similarly, conventional agriculture is not defined. Since the two forms are discussed as separate entities in the NRC report, they are similarly approached by the reviewers.

The report uses case studies as examples to support its proposition that alternative agriculture is more profitable and desirable. However, no equivalent studies on conventional farms are presented. The cases cited are also too few, of limited applicability, and not tested in a manner consistent with generally accepted scientific methods. Expanded applied interdisciplinary research concerning effects of agriculture on social, economic, and environmental factors is needed.

Alternative agriculture is viable in some situations, under certain economic conditions, at specific locations, under appropriate management expertise, and with a receptive market. In addition, the choice of farming systems is influenced by a wide range of federal policies (e.g., price supports). Alternative agriculture relies on various techniques that were innovative when first introduced and which became common practices when adapted as part of conventional agriculture (e.g., crop rotation, conservation tillage, and integrated pest management [IPM]). Hence, delineation between alternative and conventional agriculture becomes indistinct, and the difference becomes one of philosophy. Therefore, neither can be clearly defined as a separate entity with advantages over the other in all agricultural enterprises.

Practicability of some alternative agriculture practices is not well established; thus, their national adoption at the expense of conventional agriculture practices is open to discussion. The possible additional costs for equipment, buildings, labor, and management expertise for diversified systems and alternatives have to be absorbed by increased commodity prices if yields are lower.

Both benefits and risks are involved in converting from conventional to alternative agriculture or vice versa. Either change will eliminate or alleviate some problems, but create or enhance others. Problems associated with either alternative or conventional agriculture are both real and perceptual; their levels of importance vary with factors including location, economics, society, environment, social values and attitudes, governmental policies, and management.

Lowell S. Jordan

3

Summary

The report, *Alternative Agriculture*, by the National Academy of Sciences-National Research Council (NAS-NRC) (1989), addresses several aspects of agriculture and discusses systems that it indicates are environmentally and economically superior. The magnitude and complex nature of agriculture almost guarantees the existence of points upon which scientists will disagree. It is impossible to comprehensively cover the subject either in one book or one review.

The NRC report attempts to compare alternative agriculture and conventional agriculture without clearly defining either term (Watson[1]). As a consequence, reviews of the NRC report are varied. Some reviewers indicated agreement with aspects of the NRC report; others disagreed with assumptions and conclusions presented. Even the difference between alternative agriculture and conventional agriculture was questioned by reviewers; the NRC report, however, indicates, while practices and methods may be the same, the difference is one of overall philosophy. The differences in philosophy were not explained. However, the NRC report does indicate that "advocates and practitioners" of alternative farming systems include those "individuals who adhere to philosophies that advocate nonconventional farming systems." (page 136)

One of the problems identified is the difficulty in differentiating between alternative and conventional agriculture. The lack of clarity in the definitions of the two systems is illustrated by the following statement from the NRC report: "Conventional and alternative systems may use common practices or methods, but they usually differ in overall philosophy." (page 425) Thus, there are times in which both "common practices or methods" and "overall philosophy" are similar, yet one system would be designated as alternative and the other conventional by persons with different persuasions.

---

[1] Method of citation: page or case study numbers refer to citations from the NRC report, *Alternative Agriculture*; names refer to specific reviewers in the CAST document, *Alternative Agriculture: Scientists' Review*.

Differences in philosophy cannot be subjected to scientific analysis. However, the goals of the NRC report and the CAST reviewers concerning human health, human and animal welfare, and the environment are the same. Scientists differ in their perspectives of the values and problems involving various components of different agricultural systems. This summary will address scientific issues covered in the reviewers' comments and the NRC report.

Several topics were covered in the NRC report and by the reviewers. This summary is presented in sections. They are: agricultural chemicals; fertilizers, manures, and legumes; animal production; environmental factors; economic issues; social factors; food safety; diverse systems; alternative and conventional comparisons; research; government policy; and philosophical aspects.

AGRICULTURAL CHEMICALS

The use of agricultural chemicals, including pesticides, has been credited with several benefits, including reduction of labor requirements, increased crop yields, lower food costs, and higher food quality. The use of some chemicals, especially pesticides, has caused concern over water pollution, food safety, worker safety, and environmental quality. Jacobsen indicates that the NRC report dwells generally on negative aspects of agricultural chemicals and does not adequately address their benefits.

Pollution

Reviewers have different opinions concerning pollution from agricultural chemicals and their effects on the environment. They agree pollution is undesirable but differ on (1) the actual hazards posed by the different pollutants and (2) practices that would minimize pollution. Paulsen, for example, agrees that "nitrates are a significant water pollutant." He suggests reduction of nitrate pollution by careful use of manure and monitored use of nitrogen fertilizers. Reeder, however, questions the extent of nitrate pollution from agricultural practices. Osweiler indicates that the methemoglobinemia discussion in the NRC report on the standard set for nitrates may mislead the public, as it is the standard set for infants. The NRC report does not cite any data concerning injuries and/or deaths resulting from nitrate contamination in drinking water.

The NRC report also does not distinguish between nitrates in the groundwater that resulted from synthetic fertilizers or organic sources. This inability to differentiate among sources of nitrate makes it difficult to determine the precise origin of nitrate pollution. J. F. Marten notes that the highest nitrate pollution is in a region where alternative agriculture principles are practiced. J. F. Marten also mentions problems encountered using manures to supply nitrogen to a crop.

The NRC report addresses pesticide pollution of the groundwater (e.g., Table 2-6, page 106) by indicating which pesticides have been found in the groundwater, but not (1) at what concentrations they occur and (2) the hazards at those concentrations. The NRC report also discusses pollution of surface water; however, it does not differentiate between pollution from agriculture and other sources. For example, the New River in California is cited as being polluted from agricultural chemical runoff (pages 114, 116). The main source of pollution of the New River and the reason for closure to public access is untreated sewage from Mexicali, Mexico.

Fogleman discusses levels of detection of pesticides in relation to risk due to their presence. Analytical chemistry is so precise, it is possible to detect extremely low levels of a chemical. However, "no mention is made of the degree of hazard such a concentration means in terms of human or environmental impact." (Fogleman)

Osweiler notes that "since not all pollutants can be reduced with equal ease or speed, some attention should be given to prioritizing risks from various pollutants." Knake recommends classification of pesticides for groundwater-pollution tendency and health risk. Risk/benefit analysis is needed for any component of a system that is potentially harmful.

Hahn cautions that agriculture is not the major culprit in environmental problems. Farmers are concerned with pollution and the environment.

Pesticide Use

The NRC report states that alternative agriculture is any system that uses nonchemical means in place of off-farm inputs (e.g., agricultural chemicals). G. C. Marten and Duffy note the NRC report does not advocate complete elimination of pesticide use. Fogleman indicates, however, that "the impression given in the National Research Council report is that pesticides are bad, and every effort should be made to eliminate them." Knake states "it should be recognized that some pesticides can be very beneficial and contribute greatly to resource conservation, reduced inputs, and sustainability." Duffy and Knake indicate that pesticide use is not an end in itself; any control method must be viewed according to the purpose for use, namely to manage a pest.

Integrated Pest Management

Integrated Pest Management (IPM) is widely practiced for insect control in conventional agriculture and is an important part of alternative agriculture. However, as Sweet notes, IPM "has been used successfully mostly with insecticides and to a limited success with fungicides but with little or no change for herbicides or nematocides." Abernathy also addresses the difficulty in controlling weeds without herbicides.

Jacobsen comments "The discussion of alternative plant pathogen control and integrated pest management (IPM) leaves the uninformed reader with misimpressions and a naive concept of modern agroecosystems and plant disease control, in particular."

IPM has also failed to adequately control nematodes (Dickson). Dickson states the "committee's statements on alternative nematode control are inaccurate and show a lack of basic nematological practices and strategies for managing nematodes." Lee and Guenthner indicate "a number of . . . pests . . . cannot be controlled by nonchemical means." One means of nonchemical control is to use biological agents. Biological controls are designed to be highly specific and do not function well for a broad spectrum of pests in a variety of environments. Even if a biological agent is used instead of a pesticide to control a pest, that organism may become a pest itself (e.g., Fawcett).

While one intent of IPM is to reduce pesticide use, it may result in increased pesticide applications. The NRC report acknowledges that "it may be necessary . . . to retain some of the more hazardous compounds to control occasional outbreaks of certain pests" under IPM systems. The NRC report does not address (1) the pests, (2) the conditions, (3) the time frame, (4) the acceptable hazards, and (5) the permitted hazardous pesticides needed.

Pest Resistance

As the NRC report indicates, some pests can become resistant to some pesticides. This acquired resistance makes the pest(s) more difficult to control. Pests can also acquire resistance to naturally occurring compounds that may be relied upon for their control.

Miller notes that moving to an alternative system can also result in a shift in the pest population to those that resist the new control method. Consequently, multiple and rotational control methods are standard practices in good pest management programs.

Jacobsen indicates the difficulty in using several cultural controls in multiple cropping. The techniques that benefit one crop may harm another. The limitations of crop rotations and negative effects of some rotations are not addressed in the NRC report.

FERTILIZERS, MANURES, AND LEGUMES

The NRC report places considerable emphasis on the use of on-farm nitrogen fixation and nutrient cycles to replace off-farm inputs, including chemical fertilizers. Fertilizers, manures, and legumes may be alternative methods of supplying nitrogen for crop growth. The optimum method is often site-, crop-, and grower-specific. Chemical fertilizers are considered to be off-farm inputs. Even manure can be considered an off-farm input if it is transported to the farm from another location.

Manure has been used for centuries for its nutrient content and soil-amendment qualities. While it can be a useful product, there are problems with manure use. Not all of the nutrients contained in manure are available for plant use (page 152). In addition, larger numbers of animals would have to be raised to produce the manure needed to supply nutrients to crops (Lee and Guenthner). The manure produced for its fertilizer value must have a market. If it has lower value than a commercial counterpart, it will be disposed of as a byproduct (Duffy). If the demand for manure were to appreciably increase, without a concurrent and proportional increase in its supply, its price would increase, resulting in a lower profit margin.

Manure, Pollution, and Health

The NRC report does not adequately address the pollution and health problems of adding large quantities of manure into the environment. Paulsen believes that manure application may reduce nitrate pollution of the groundwater. However, Walker states that manures "may have a pollution potential which may be greater than that with commercial fertilizer, depending on the nutrient management practices employed." Other reviewers indicate that soil, surface water, and groundwater may become polluted by manure.

Watson states that sludge/manure mixtures can pollute "the soil with heavy metals." Manure dust and gases from its decomposition (e.g., ammonia, methane, hydrogen sulfide in anaerobic conditions) can be air pollutants. Nitrate from manure can pollute water (Walker, Zimmerman). Some of the nitrogen is not readily available since it depends upon decomposition of the organic matter which contains it.

Manure use may result in an increase in the "coliform contamination of underground water supplies" (Walker). The coliform bacteria (including *Salmonella* and *Shigella*) can cause bacillary dysentery, typhoid and paratyphoid fevers, and food poisoning. Coliform bacteria are transmitted to water largely through fecal matter. In addition, houseflies thrive on manure, invade dwellings, and carry disease organisms to food. Pesticides may be required to control the flies around manure.

Manure is a conglomeration of a vast number of organic and inorganic compounds. The safety, health, and environmental pollution potential of all the components of manure have not been determined. Risk/benefit analysis of manures from different sources is needed.

Value of Manure

Manure production and utilization have problems. Manure is bulky (it is 50 to 80% water), difficult and unpleasant to handle, expensive to transport, odoriferous (especially in anaerobic conditions), dirty, possibly disease-ridden (animal and plant) and weed-seed infested.

In pasture settings, manure collection is complicated because of its unequal dispersion. Also, if manure is mechanically broadcast over a pasture, livestock may refuse to consume the plants that are contaminated with feces. Manure may also serve as a fertilizer source for the weed seeds deposited with it.

Manure varies in nutrient content and quality (Duffy). Manure quality varies according to the animal that produces it and the manner in which it is stored and handled. Nutrients can be lost from the manure, lowering its quality.

Changes of Fertilizer Source

The effect on crop nutrition of changeover from chemical fertilizers to manure as the fertilizer source of nutrients other than nitrogen is not immediately discernable. Nutrient depletion in the soil can take time, even decades, before the response curve breaks downward with respect to yield (Miller).

The NRC report notes that manures might not provide the required nutrients when needed. Even if the manure is correctly applied, only a fraction of the needed nitrogen, phosphorus, and potassium is economically recoverable.

J. F. Marten discusses two long term studies concerning manures, crop rotations, and chemical fertilizers that yield the same conclusions. The highest corn yields occur when chemical fertilizers were used. The NRC report did not emphasize the comparisions among different fertilization regimes.

Regardless of the source of nutrients, no crop is 100% efficient in using the available nutrients in the soil. One attempt to increase availability of nutrients and decrease pollution is to band them. This permits fertilizers to be in the immediate root zone where they are needed by the crop. The NRC report did not address the banding of fertilizers to reduce pollution. Manures are not banded; thus, some of their nutrients will be unavailable to the crop and could become pollutants.

Legumes

There is little doubt concerning the numerous contributions of legumes to agriculture. They may fix nitrogen and, under the proper conditions, may furnish it for themselves and succeeding crops. Under other conditions, however, legumes may help deplete the soil nitrogen. They may increase organic matter content of soils under proper environmental conditions. The positive attributes of legumes are acknowledged by the NRC report; another alternative to chemical and/or manure use is the use of legumes to fix nitrogen. Legumes may have an additional benefit in terms of weed control (Knake).

Black puts the use of legumes into a different perspective; "legumes do not supply as much nitrogen as usually desired." Under some conditions, legumes can even use more nitrogen than they fix. Legumes also produce nitrates which, like nitrates from synthetic fertilizers, can be polluting (Black). Furthermore, it may be more difficult to control nitrate pollution from legumes and manure than by chemical fertilizers (Fawcett).

Legumes use water and nutrients for growth like any other crop. In areas where water is normally scarce and during drought years, farmers may not be able to afford to use legumes to replace fertilizers. Legumes also must be supplied with nutrients other than nitrogen when they are lacking.

ANIMAL PRODUCTION

Animal inclusion is and will remain an important component in many farming systems. Often the choice of including animals in a farming operation will be determined by the nature of the unit, preferences of the management, and the presence of a market for the product.

If livestock production is increased, land might be diverted from other uses (e.g., crop production, forests, wildlife habitats, parks, watersheds) to support the livestock. Increased livestock production also requires an increased market for meat and dairy products (Lee and Guenthner). The health aspects of increased animal products in the human diet are being debated.

Subtherapeutic Antibiotic Use

There are many complicated issues involving the use of drugs for disease control in animals. Any drug use requires much research prior to utilization, and strict monitoring during its use. Animal drug use is widespread; the NRC report indicates it improves both feed efficiency and growth rate of livestock.

Zimmerman emphasizes that "the potential risks, both real and perceived, associated with the use of antimicrobials in animal agriculture warrant the goals of proper and minimum use of these compounds."

Russell indicates that the NRC report presents errors with regard to antibiotic use. He notes that the NRC report did not report the following: that chloramphenicol was banned for use in food animals in 1984; that gentamicin is not only available through veterinarians, as indicated in the NRC report, but also in over-the-counter products. According to Russell, some statements made in the NRC report about treatment of animals are "an affront to current emphasis in veterinary medical education and private veterinary medical practice." Trenkle also points out that timing of antibiotic use (in addition to dosage level) is important.

Confinement of livestock was addressed by both the NRC report and some reviewers. Osweiler indicates that antibiotic residues are less in well-managed, highly concentrated, integrated units of animal and poultry production than in smaller and more independent operations. Russell also notes that well-managed confinement systems utilize good preventive veterinary medical practices that lower both disease incidence and veterinary medical costs. Trenkle emphasizes that subtherapeutic use of antibiotics does not substitute for good management; good management practices are part of well-managed farms.

The importance of disease prevention in livestock production is not controversial; however, the means of disease prevention are discussed. Russell comments that the NRC report errs when it indicates that the subtherapeutic feeding of antibiotics and the antibiotic treatment of diseased animals is the focus of current animal health practices; it ignores commonly practiced herd health programs and livestock management practices.

Breeding

The NRC report states that one of the goals of alternative agriculture is to increase both biological and genetic potential of animals. Hohenboken cites several successful breeding programs.

Case Studies

Russell notes the Thompson farm (Case Study 5) has animals that "would have a very high risk for exposure to numerous soilborne pathogens, which could result in devastating losses from animal diseases and deaths." Zimmerman comments that statements are made about the Thompson farm case that are not supported by scientific evidence.

ENVIRONMENTAL FACTORS

The environmental factors addressed both by the NRC report and some reviewers are water, soil erosion, weed control, and environmental goals. Alternative agriculture, according to the NRC report, focuses on soil, water, energy, and biological resources conservation.

Water

Fawcett reports that nitrates from legumes and manure can pollute the groundwater. He also points out that the groundwater has not been tested for nitrates in any of the case studies. Watson indicates that the nitrate testing should be required in studies about groundwater; he also notes that the condition of the wells is not mentioned in the case studies.

Soil Erosion and Weed Control

The NRC report emphasizes that some form of conservation tillage is needed to help reduce soil erosion and discusses problems associated with the practices. Fawcett also addresses the subjects of tillage, soil erosion, and related problems. He notes that while tillage is the major alternative to herbicides for weed control, it can lead to increased soil erosion. Aldrich points out that soil erosion results from increased tillage of many soils and depends upon slope of the land.

Tillage, as a method of weed control, involves tradeoffs. Miller points out that herbicides are used so that wet weather will not prevent weed control (from tillage). He also states that "more farm operations have one or more persons employed off the farm, thereby reducing the opportunity and incentive for alternative weed control strategies." Normal tillage results in increased soil erosion, which can be reduced by conservation tillage. According to the NRC report, conservation tillage may increase the need for herbicides. Tillage also increases the need for energy to move equipment across the field (Knake).

Environmental Goals

According to Fawcett, "presumably the ultimate goal of changes in agriculture is to improve environmental protection, human health, and sustainability and profitability of farms. Curiously, little or no data are presented to show that alternative farming systems will meet this goal."

ECONOMIC ISSUES

The NRC report indicates that "It is difficult to estimate the economic impact of many alternative farming practices, particularly those that influence several aspects of the farm. . . . Even more difficult is the task of predicting the economic effects of the transition to alternative methods." (page 7) Later, the NRC report states that "At the aggregate level, the committee could identify no useful studies of the potential effects of widespread adoption of alternative agricultural systems." (page 196)

While not specifying the aggregate impact of widespread adoption of alternative agriculture, the NRC report indicates that "many farmers have begun to adopt alternative practices with the goals of reducing input costs. . . ." (page 3) The NRC report addresses economic hardships caused by conventional agriculture. However, it does not equally address economic hardships that would develop as a consequence of alternative agriculture. Determination of the reasons for failures of conventional agriculture may be as important in developing alternative systems as understanding reasons for success.

Economic issues were also addressed by reviewers. Devlin and Osweiler both question the widespread change to alternative agriculture without knowing the consequences. Hohenboken indicates that increased livestock production would contribute to additional national export income. Meanwhile, Osweiler questions the ability of the market to absorb increased livestock production. Carter also asks (1) who will buy the additional forage and beans produced under alternative agriculture, and (2) what will be the effect on established domestic and export markets for the other crops.

Sweet indicates that there was no evidence that purchases of annual inputs such as pesticides, fertilizers, etc., for conventional systems were a significant factor in bankruptcies in the 1980s. Fawcett and J. F. Marten note that since 1980, fertilizer, insecticide, and herbicide use have actually declined.

Case Studies

The NRC report utilizes 11 case studies as examples of the economic viability of alternative agriculture. Gianessi indicates that, upon "follow-up of several of the case studies . . .", he determined that one farm went out of business and others increased "their reliance on chemical inputs for economic sustainability." To remain economically viable, alternative agriculture, as presented in the case studies, relies on higher prices (page 9, Miller, Bradley, Aldrich, Black). The higher prices, however, did not always yield a profit; losses were still possible (Black, Case No. 10, Case No. 11). In Case No. 3, the farmer included Johnsongrass as part of their hay crop; however, Johnsongrass hay has caused serious cattle losses from cyanide poisoning.

J. F. Marten also makes several statements about the case studies, including (1) lack of follow-up study, (2) loss of money from some of the case farms (even with premium prices), (3) bankruptcy of one farm, (4) an angry letter he received from the farmer who was interviewed only once and whose wife taught only one year, (5) emphasis on case studies while de-emphasizing some long-term research, (6) replacing a small amount of insecticide with much more fungicide in one case, and (7) that one case "doesn't even exist."

SOCIAL FACTORS

Widespread adoption of alternative agriculture would impact both rural and urban society. The effects of changes in agriculture on the U.S. social structure have not been adequately addressed.

Labor

Alternative agriculture would require more labor, especially trained labor (NRC report, Flora). However, the solution for attracting more qualified scientists to agricultural pursuits and obtaining the skilled labor was not developed in the NRC report. At present, rural labor is scarce at peak requirement periods (Lee and Guenthner) and may be in excess at other times. The problem of rural labor increases when farm family members are employed off the farm (Miller).

Management Skills

The NRC report indicates that increased management skills will be necessary under alternative agriculture systems. Unfortunately, the current emphasis at universities is on basic rather than applied research. Research and management training is concentrated in nonagricultural disciplines. These deficiencies must be addressed if use of alternative agricultural methods is to be increased.

Legates questions whether the financial benefits from alternative agriculture will sufficiently reward the increased management inputs. Carter notes that "Yields may be lower; quality may be less." Therefore, increased profits would be unavailable for paying the highly skilled management.

Diversification of Systems

Expansion of farming operations into diversified systems may not always be acceptable. Miller notes several social acceptance factors that may cause resistance to adoption of alternative agriculture. Furthermore, the expansion of cropping systems into livestock production, or vice versa, may not be possible in all situations.

FOOD SAFETY

Food safety is of national concern. It is difficult for the ordinary consumer to determine whether or not the food available to him or her is safe to eat. Both the NRC report and the reviewers discuss this important topic.

The NRC report comments on the health hazards of high levels of, or prolonged exposure to, a number of agricultural chemicals. The NRC report also indicates that there is little information about the health hazards of pesticides and a lack of accurate exposure data. Sweet notes that long-term exposure studies have been and are being conducted; he discusses a long-term study in Canada as an example. Sweet also cites several studies, including one with 13,000 samples in California, and concludes that our foods are safe.

Both the NRC report and reviewers indicate that naturally occurring chemicals produced for pest and weed control can pose health problems. Fawcett, Jukes, and Lee and Guenthner discuss the prevalence of toxic substances that occur naturally in food. According to Lee and Guenthner, the organic product may be more hazardous to human health than conventionally produced foods. Jacobsen refers to alkaloid toxicity in a disease-resistant potato variety and warns that a closer evaluation of plant-produced compounds will identify other situations where disease resistance creates a food safety problem.

Jacobsen states that pesticides are used to reduce losses in the production field and postharvest environments, not just to meet "blemish-free grading standards." He also indicates that the NRC report does not address toxins (mycotoxins) produced by fungal plant pathogens that attack fruits and vegetables. Miller states that we also owe the consumer risk assessment data on residue levels as well as the risks, if any, of food produced without synthetic chemical resources.

Fogleman warns that drawing conclusions from toxicological studies can be difficult. For example, "finding a change in an organism may or may not be toxicologically significant. Further, extrapolation of toxicity data from one species to another is extremely difficult, and subject to much debate in scientific circles" (Fogleman).

Grading Standards, Marketing, and Consumer Acceptance

The NRC report advocates changing federal grading standards with regard to cosmetic appearance and insect-part criteria, which it claims have little (if any) relationship to nutritional quality (page 12). Lee and Guenthner point out that insect, nematode, or wireworm infestations (e.g., in potatoes) can permit entry of spoilage bacteria and fungi that can lead to serious food quality and safety problems. Black emphasized that microorganisms that cause surface blemishes may hasten the deterioration of the product or produce toxins. Quality standards may be important to protect the consumer from toxins (Lee and Guenthner) and permit international competition of American farm produce (Devlin).

The NRC report indicates that consumer acceptance of modified grading standards and higher prices for foods can be addressed by changing consumer attitudes through public information efforts. Russell questions whether American consumers will accept lower quality products. Lee and Guenthner also doubt that consumers will accept food that is of inferior quality, more prone to spoilage, possibly risky to human health, and higher priced.

Food and Fiber Quantity

Overall food and fiber quantity from widespread adoption of alternative agriculture was not addressed in the NRC report. J. F. Marten questions whether alternative agriculture will be able to provide enough food to feed a growing world population.

Aldrich predicts a reduction of food supply by at least 15% if there is "widespread replacement of conventional agriculture with the NRC committee's version of alternative agriculture." Tweeten and Helmers predict a reduction in food by up to 26% with widespread adoption of alternative agriculture practices. The reduction in food supply and increased price of food would especially affect low-income persons (Tweeten and Helmers, Aldrich).

DIVERSE SYSTEMS

One way to diversify farms and reduce off-farm inputs, according to the NRC report, is to increase the use of crop rotations. Crop rotation has long been accepted as crucial to many good farming systems. However, Aldrich indicates that crop rotation is not always beneficial. Furthermore, Knake indicates that crop rotation is not always feasible and that, in some instances, monoculture is the only option (e.g., orange groves and apple orchards). Inclusion of legumes in a rotation may necessitate development of annuals in the enterprise. Implications of this inclusion are discussed in the section on fertilizers, manures, and legumes.

ALTERNATIVE AND CONVENTIONAL AGRICULTURE COMPARISONS

The NRC report addresses alternative and conventional agriculture as being systems. A system is an overall approach to agricultural production and a combination of methods. The NRC report also indicates that, while conventional and alternative agriculture may use the same practices or methods, they differ in philosophy. The difference in philosophy is not explained in the NRC report.

Watson believes that alternative agriculture has become a goal in itself. Aldrich states that the NRC report does not fairly compare the two agricultural systems by being too optimistic about alternative agriculture and not adequately crediting conventional agriculture with changes made.

RESEARCH

Both the NRC report and reviewers agree that more applied agricultural research is needed. They may differ in the approach by which the research is conducted.

Goals

The NRC report indicates that agricultural research has focused on individual crops and disciplines and has not emphasized an interdisciplinary approach. According to the NRC report, agricultural research has not been organized adequately to solve interdisciplinary problems. Some reviewers agree with this statement.

Abernathy states that interdisciplinary research is being conducted in the agricultural experiment stations. Aldrich indicates that the NRC approach underestimates the capacity of modern farmers to put together systems well adapted to their soil, markets, financial resources, and personal characteristics. Hahn also states that farmers are constantly using alternative methods. Black cautions that new technology is adapted only when it is proven to be successful and economical.

Problems encountered in conducting interdisciplinary research include institutional constraints (Carter), available funding (Dickson), multiple authorships (Dickson), tenure and promotion (NRC report), and ability of individual researchers (Legates). Abernathy notes that more research funds and coordinated efforts are justified for interdisciplinary research.

While the interdisciplinary and/or systems approaches may be useful in some cases, caution about using a systems approach is presented by Knake, Aldrich, Miller, and Legates. By using a systems approach, it becomes extremely difficult to establish cause-and-effect relationships. Legates notes that "a systems approach to research is necessary, not on its own, but as a complement to intensive specifically oriented research."

Case Studies

The NRC report states "Case studies provide insights into how the real world works. They help formulate and test hypotheses, but cannot substitute for other forms of scientific research." (page 247) Carter indicates that "Much of the research so far on sustainable farming systems is based on case studies which are only suggestive of positive outcomes." Duffy states that "case studies had to be used because of a lack of systems research." Furthermore, Hohenboken states that the NRC should have presented "a like number of failures of alternative enterprises. Such cases surely exist." Giānessi takes a another view. He states that the NRC case studies are data-deficient. He indicates that questions were left unanswered, case studies were not up-to-date, and quantified answers were not given.

GOVERNMENT POLICY

The NRC addresses different aspects of government policy, including commodity programs, regulations, research, and food grading and cosmetic standards.

Commodity Programs

Much of the emphasis about government policy in the NRC report was on commodity programs that have affected the production of controlled crops. Some reviewers agree that commodity programs restrict the choice of a crop that participants can plant. The NRC report indicates that the majority of commodity crop acreage is enrolled in federal commodity programs. However, the NRC report does not compare acreage that is not enrolled in federal commodity programs with acreage that is enrolled. Furthermore, not all crops, e.g., potatoes (Lee and Guenthner), are subsidized by the federal government.

J. F. Marten makes several comments about the discussion of commodity programs in the NRC report. He indicates (1) less of the nation's cropland is involved than claimed, (2) penalties reported as possible by the ASCS do not occur, (3) the ASCS does not forbid rotation crops, (4) rye is not a program crop, (5) beans do not have a target price or a program, and (6) farmers do not indicate that farm programs make them use more chemicals.

Impact of Federal Regulations

Fogleman and Flora address the importance of the impact of federal regulations, policies, and statutes on agricultural practices. Fogleman also addresses the concept of educating the public; a topic also discussed in the NRC report. He cites a number of erroneous beliefs held by members of the public regarding agriculture.

Regulations Proposed by NRC Report

The NRC report proposes re-educating consumers about the relationship of food and safety. It also proposes a change in the control of the supply and price of fruits and vegetables. However, it does not explain in detail the proposed changes. Aldrich disagrees with the NRC proposal regarding changing control of the supply and price of food items.

PHILOSOPHICAL ASPECTS

It may be difficult to distinguish between alternative and conventional agriculture. The NRC report indicates that, although the same practices may be followed by both, the difference is one of overall philosophy. Differences in philosophy cannot be solved by scientific methods. Also rhetoric cannot solve scientific problems.

The debate over alternative and conventional agriculture will continue; only research and practical applications will answer the many questions. However, we must all work together to achieve the common goals "of improved protection of the environment, sustainability of agriculture, human health, and profitability of farms." (Fawcett)

Lowell S. Jordan
James L. Jordan

Scientists' Reviews

4

Agricultural Engineering, Food Science, and Toxicology

Alternative Agriculture

Ralph W. Fogleman
Upper Black Eddy, Pennsylvania

SUMMARY

This review of the National Research Council report, *Alternative Agriculture*, prepared at the request of CAST, expresses my own views, and not those of CAST or the International Society of Regulatory Toxicology and Pharmacology.

The report emphasizes that the use of chemicals in agriculture should be reduced, and that biotechnology will provide the needs of agriculture. The report contains many valid points, but ignores the impact of the public misconceptions of agriculture and science which is driving public policy and regulatory activity, and which must be considered if the abundant and safe food supply is to be maintained.

Five major points are discussed which emphasize the areas of concern.

REVIEW

This review of the National Research Council report *Alternative Agriculture* has been prepared at the request of CAST and as the representative of the International Society of Regulatory Toxicology and Pharmacology (ISRTP). The opinions expressed are exclusively mine and do not reflect the position of ISRTP or CAST. As an independent consultant in the field of toxicology and regulatory matters for the past 15 years, and with a previous 22 years of experience in the consulting laboratory business, as well as owning farmland in northwest Kansas, I view the National Research Council report from both a scientific/regulatory and a practical standpoint.

First, in the second paragraph of the Executive Summary, it states that "pesticides . . . are detected in the groundwater in many agricultural regions." The key word is "detected." Modern analytical chemistry can detect exceedingly small quantities of any chemical. From a toxicologic point of view, Paracelcus made the point that "the dose makes the poison." Detection of one microgram or 0.000001 gm (1 X 10^{-6} gm) of a substance in 1,000 gm (or cc) of water, is not of and by itself a significant finding. This quantity is one part per billion (1 ppb). Most pesticides are detected in this range (see pages 101-103). No mention is made of the degree of hazard such a concentration means in terms of human or environmental impact. Under the Clean Water Act, it is implied that any detectable amount is to be avoided, and a strict interpretation of that law could have a serious impact on agricultural production without a concomitant benefit.

Second, the report does well to emphasize the impact of government regulations, policies, and laws on the agricultural practices. Such policies have far reaching effects and will eventually reach the consumer. Agricultural practice has changed over the past 40 years from a small, self-contained family where much of the food was raised on the land and the need for hard cash was limited, to the highly organized and well financed agribusiness of today where intense agriculture is necessary to provide for the equipment used to replace the loss of on-farm labor. As pointed out by the National Research Council report, less than 2% of the working population is engaged in agricultural production, and this 2% is feeding the rest of the nation and providing food for export as well. Today, the economics of farming almost preclude the youth from becoming farmers because of the high capital investment, and as the report points out, for many, additional off-farm income is necessary for survival.

The report states that today's agriculturalists are well educated, highly skilled, and willing to adopt new practices. Much of what is proposed as "alternative" agriculture is nothing more than progress as new knowledge and experience is brought to bear. Already, consultant agriculturists are employing the principles of integrated pest management and recommending new techniques by scouting for insects and new techniques for weed control and soil fertility. In northwest Kansas, as an example, the usual 3-year rotation is wheat, grain sorghum, and summer fallow, and is controlled by government support programs. No-till or 'limited' tillage has been practiced for years because of the need to preserve moisture and prevent erosion. Pesticide chemicals are used only in limited quantities. But with the reduction in acreage allotments of 20%, the use of liquid nitrogen has been employed to increase the yields. A similar situation does not exist in a farm area such as eastern Pennsylvania, where fields are small and usually located in valleys with abundant moisture. These farms rarely are as highly crop-intensive as the production of wheat, corn, soybeans, and other commodity crops in the Great Plains states.

Third, the regulatory atmosphere associated with pesticide development and usage is a serious impediment to agricultural production. The impression given in the National Research Council report is that pesticides are bad, and every effort should be made to eliminate them. Recent rules and regulations issued by the Environmental Protection Agency under the 1988 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act

(FIFRA), and public comments made by agency spokespersons appear to support this view.

Toxicology is the study of the adverse effects of a xenobiotic on an organism, and embraces both humans and the environment. Hazard is the probability that harm will result from a given exposure (or dose). Paracelcus stated that "the dose makes the poison," and it seems that this basic fact is omitted from the consideration by the media, the environmental activists, and some members of Congress. Toxicology is also an applied science which draws on the basic sciences of biochemistry, physiology, pharmacology, organic chemistry, anatomy, microbiology, and physics in devising its data. Finding a change in an organism may or may not be toxicologically significant. Further, extrapolation of toxicity data from one species to another is extremely difficult, and subject to much debate in scientific circles.

Government regulations have been chosen to select the conservative estimates of safety from extrapolated data, and there is nothing wrong with such a position. However, when scientific evidence dictates a change, the regulatory position should also change. Unfortunately, such policy is driven by uninformed public opinion, rather than rational thought. There is serious conflict between the scientific community and the regulators on interpretation of data, particularly on carcinogenesis. The Delaney Amendment to Section 408 of the Food, Drug, and Cosmetic Act is not scientifically supportable except within the concept of banning all chemicals from food. If that is, indeed, the thrust of public policy, one may expect a significant decrease in the quality, quantity, and safety of food.

Fourth, biotechnology and genetic engineering are emphasized in the report as a means of improving crop production. However, this is a double-edged sword, in that new fields of science are being opened up and there is no foundation within the sciences on which the decision makers can rely in evaluating safety. In this arena, flexibility must be built into the regulations so that new information can be rapidly utilized. The Environmental Protection Agency's Subdivision M Guidelines for biologic pesticides, issued last year, suggest some flexibility, but experience has shown the guidelines tend to be rigidly enforced. While this serves the industry by outlining the development procedures and estimation of costs, it does not necessarily serve the public interest when decisions are delayed.

An article in *Science* (Culliton, 1990) raises the spectre of virus mutation in nature, giving rise to "new" viruses which can cause pandemic disease, such as acquired immunity deficiency syndrome (AIDS) or flu. This suggests that genetically altered organisms, plants, insects, or bacteria may also mutate further as they compete on an evolutionary scale in the environment. Until science can predict and evaluate the potential, I take the view that I would prefer my children and grandchildren be exposed to a few milligrams of some well-studied chemicals in an abundant food supply than to essentially unknown organic complexes resulting from genetic manipulation.

Fifth, the National Research Council report emphasizes the need for education of agricultural scientists to better understand the on-farm problems. There is an equal or greater need for strong support in educating the public on the importance of agriculture. While it sounds ridiculous on the surface, there are people who feel that farms are unimportant because we have supermarkets. Sixth graders in urban areas have no concept about milk production—to them, milk comes in a carton. Two Rutgers professors recently suggested that the "wasteland" from west of the Mississippi to the foothills of the Rockies, and from Canada to Mexico be converted into a national park and allow the return of the wild buffalo herds. These are only a few examples of the gross misunderstanding the general population has developed about agriculture. The industry is very much aware of this because it is reflected in public policy and political pressures, but has been unable to correct the misconceptions. When we run out of food and farmland, it will be too late to rebuild the infrastructure, and it can reasonably be predicted that we will reach that catastrophic event in the foreseeable future under current policy.

Conclusions

1. The National Research Council report contains many valid points which emphasize the public concept of agriculture today, as well as details of many of its problems. It can be criticized by its strong emphasis against the use of pesticide chemicals and its optimistic view of biotechnology as a replacement.

2. The recommendations for change in farm and environmental policy are very well taken. The need for regulatory change, however, as implemented by the 1988 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act, has and is resulting in a loss of a significant number of pesticides without suitable alternatives. The necessity of scientific input in regulatory matters must be considered by the policy makers and enforcers. The research and development goals appear reasonable and worthy of support.

3. The report should expand its education recommendation to include support for educating the general public on the importance of agriculture.

Literature Cited

Culliton, B. J. 1990. Emerging viruses, emerging threat. *Science* 247:279-280.

Review of *Alternative Agriculture*

Richard R. Hahn
Director, Kansas Agricultural Value-Added Center
Kansas State University

SUMMARY

This report starts with the premise that alternative agriculture is a spectrum of farming systems. However, it quickly focused on two

areas—fertilizers and pesticides usage. It ignored the significant amount of work being done in other areas by our farmers, university experiment stations, and agribusinesses. Thus, the report failed to present the spectrum of alternatives that are available for farmers to adapt to their own unique situation.

REVIEW

Alternative Agriculture is a controversial and confusing subject because there is no agreed upon definition that brings the subject into perspective. This report suggests that alternative agriculture is "not a single system of farming" but includes a "spectrum of farming systems." However, the authors then begin to narrow the definition and present only a few of the alternative approaches focusing on the emotional issues of fertilizers and pesticides.

Agricultural research and farming are founded on the principle of finding alternative and improved ways to grow our crops and livestock. Each farmer adapts and changes his farming methods to meet the changes on his farm and takes advantage of the best farming methods for his own situation. This report presents alternative agriculture as a new approach which it is not. Farming by its very nature is practiced by individuals operating relatively independently who are constantly using alternative methods. Each region and farm is a different combination of climate, soil types, and conditions. The farmer that survives is the one who finds the right combination of alternatives to be profitable in his situation.

The report suggests in its overall tone that agriculture is the major culprit in environmental problems. This is not true. The vast majority of our farmers are concerned about the environment and retaining the value and productivity of the land. After all, it is their livelihood that is being affected and they are the first to be affected by pollution, erosion, or loss of productivity.

The report made four major points in its summary section. As stated on pages 5 and 6 these are:

1. "A small number of farmers . . . currently use alternative farming systems. . . ." The authors departed from their general definition to support this conclusion. In reality, many farmers use a wide variety of farming systems to meet their individual challenges for profitable agriculture.

2. "Federal policies . . . influence farmers choice of agricultural practices." Federal policies do affect choices farmers make regarding farming methods. Policies need to be developed that protect the resource base in addition to assisting farming to be profitable. It is not and cannot be an either/or situation as the authors suggest.

3. "Little recent research however has been directed toward . . . alternative systems." I wonder if the authors have looked at a broad spectrum of reports from the nation's Agricultural Experiment Stations. I find much of the suggested work is under active development in a number of locations.

4. "Innovative farmers have developed many alternative farming methods and systems." This is true. Farmers are very skilled at adapting farming methods to their individual situations. Many are not broadly used because they fit individual situations and preferences. Others need assistance for broader adoption and this assistance needs to be provided. This is exactly what our agricultural research system is good at and has been doing for more than 100 years.

Perhaps the most interesting section of the report is the case studies of eleven individual farming operations. They represent successful farmers applying the diverse farming methods that are available to them. There are many other similar examples that can be sighted to support the broad definition of alternative agriculture as a "spectrum of farming systems" where the emphasis is on profitable farming not on reduced fertilizers and pesticides or other emotional issues.

In conclusion, while alternative agriculture was intended to be a broad analysis of farming alternatives, it failed to maintain this broad perspective and focused on only a few of the many issues facing today's farmers in their struggle to be productive and profitable.

Comments on *Alternative Agriculture*

Thomas H. Jukes
Department of Biophysics
University of California, Berkeley

SUMMARY

Alternative Agriculture omits important information, such as Ames' evaluation of the toxicology of pesticide residues. There is no description of the unscientific background of organic farming and foods. The book states that the Institute of Medicine report in 1989 estimated 40 deaths per year from using antimicrobials in animal feeds, but omits the next sentence which says that these deaths might to some extent replace deaths that would occur from infection by susceptible *Salmonella* spp. if "antimicrobials had not been used." The book repeatedly speaks of harmful residues without mentioning that modern analytical technologies permit detection of levels that are biologically insignificant.

REVIEW

Much of this book consists of criticisms of conventional agricultural technology. The criticisms are practically never balanced by presenting contrasting viewpoints. I shall give a few examples.

1. **Pesticide residues in food.** Bruce Ames and his colleagues (1979, 1987,

1989) have spent years of research on evaluating carcinogens in the food supply. Their conclusions are that 99.99% of pesticides are natural and that residues of synthetic pesticides in food and drinking water are not a major carcinogenic hazard.

Why is this not mentioned in the book?

The Food and Drug Administration ranks pesticide residues as presenting lower potential hazards in foods than pathogenic microorganisms, malnutrition, environmental contaminants, or natural toxicants (Foster, 1990).

2. **Sulfamethazine as a carcinogen.** The book states (page 129) that sulfamethazine "may be carcinogenic in rodents," without saying why. Such an allegation should be thoroughly explained. Sulfamethazine (SMZ) has been reported to produce "tumors in the thyroid glands of rats and mice." This was completely predictable. This is a property common to sulfonamides, because they are goitrogens as described years ago in the standard text by Goodman and Gilman, *Pharmacological Basis of Therapeutics*, 5th Edition, 1975, page 1122 (Goodman and Murad, 1975), also earlier by E. B. Astwood, *Harvey Lectures* (1945). Goodman and Gilman (page 1123) also note that sulfonamides are given at doses of 2 grams daily for prophylaxis of streptococcal infections and rheumatic fever. "They should be used without hesitation in patients who are hypersensitive to penicillin."

   Although SMZ is used only in veterinary medicine, it is a close chemical relative of the common human medicine, sulfadiazine. The amount of SMZ at the action level of 10 ppb in a daily quart of milk would be 10 micrograms as compared with a daily clinical dose of 2,000,000 micrograms for sulfadiazine. Granted that food is not medicine, is it likely that a carcinogen would be prescribed at such a dosage rate? There is a widespread feeling that there is no "safe dose" of carcinogens because they interact with DNA. The tumor-causing action of goitrogens, however, is not an effect on DNA. It is because they block the uptake of iodine by the thyroid gland, and thus prevent the biological synthesis of thyroid hormone. This produces a reaction in the pituitary gland, which proceeds to step up its production of the thyroid-stimulating hormone (TSH). The TSH makes the thyroid grow and, given a long enough period at a high dosage of goitrogen, it eventually becomes cancerous in rats and mice. The description by Goodman and Gilman is worth quoting, even though the language is technical.

   > "Chesney described goiter in laboratory rabbits fed a diet composed largely of cabbage (Chesney et al., 1928). . . . These experiments led to the work of Hercus and Purves (1936), who showed a clear-cut and reproducible goitrogenic effect from feeding the seeds of the cabbage family of plants. Two pure compounds were soon thereafter shown to produce goiter. Sulfaguanidine and phenylthiourea. . . . were found to cause goiter in rats. With such ready means at hand to cause goiter, the mechanism was soon elucidated.
   >
   > "When an effective dose of one of these compounds was fed to young, growing rats, the thyroid glands underwent extraordinary hyperplastic changes characteristic of intense thyrotropic stimulation. However, the animal began to eat less food and eventually to suffer a decreased rate of growth, effects reminiscent of those following thyroidectomy. It was

> then established that the animals were indeed hypothyroid. Thyroid hormone was then given, with the result that the effects of the goitrogenic agent were altogether abolished. This suggested that the goiter was a compensatory change resulting from the induced state of hypothyroidism. When the hypophysis (pituitary gland) was removed from the experimental animal, the goitrogen had no visible effect upon the thyroid gland. The conclusion was inescapable that the primary action was an inhibition of the formation of thyroid hormone. The first measurable effect in young rats was a loss of organic iodine from the thyroid; after treatment was begun, no new hormone could be made. Meanwhile the circulating hormone decreased, and compensatory hypertrophy of the thyroid followed." (Astwood, 1945)

But the goitrogenic effect on the thyroid can also be produced by withdrawing iodine from the diet of rats (Axelrod and Leblond, 1954; Greisbach, 1941; Greisbach et al., 1945). Griesbach et al. (1945) also showed that thyroid tumors were not produced when the test diet was alternated with periods of the control diet. So this puts goitrogens in a different class from substances that damage DNA. It means there must be a threshold for the action of goitrogens, and this almost certainly means that traces of SMZ in milk can have no effect on the thyroid. (Remember that patients getting 2 grams of sulfonamide a day are not considered to be at risk.)

I therefore conclude that the Food and Drug Administration tests with rats and mice fed high levels of SMZ will be meaningful only in terms of such high levels, and not in terms of the traces in milk. These traces would most likely have less physiological or pharmacological effect than eating common foods such as cabbage and broccoli.

The text continued, "Furthermore, approximately 3% of the human population is allergic to sulfamethazine and many other antimicrobial drugs that may contaminate food products. . . . " This statement is difficult to comprehend or interpret. Is 3% allergic to sulfamethazine? How could this be estimated when sulfamethazine is not used as a human drug? Allergic to what level? Is the 3% also allergic to "many other antimicrobial drugs?" What are these drugs?

The Swann Committee in the United Kingdom, in its report on the use of antibiotics for farm animals, stated that the only possible effect of residues on consumers arose from penicillin in milk from cows treated for udder infections in which the withdrawal time of the antibiotic had not been observed. Cases of skin rashes were reported from the consumption of such milk by sensitive patients. The committee commented that "there are no known instances in which harmful effects in human beings have resulted from antibiotic residues in food other than milk."

My own experience is in agreement with this. Tetracyclines were used as food additives to delay bacterial spoilage in fish (in Canada) and in poultry (in the United States) for several years, during the 1950s. This has been reviewed at length by Tarr (1984) who comments that "approved and controlled use of antibiotics in human foods as discussed in this review have not been shown to be accompanied by adverse reactions in the consumer."

Allergic reactions to almost any chemical occur in human beings, but, with the exception of penicillin, the reactions to antibiotics are rare. The widespread use of antibiotics in human medicine has indeed resulted in allergic reactions in some patients, but the common antibiotics (except penicillin) do not seem to be more allergenic than the average for other medicines. The book is "shooting from the hip" when it makes such an allegation.

3. **Antibiotics for prophylaxis and growth promotion in farm animals.** The book (pages 128 to 129) quotes the Institute of Medicine (IOM) committee report as estimating the number of deaths from salmonellosis attributable to use of antimicrobials in animal feeds for prophylaxis and growth promotion, and concluded that the likeliest estimate was in the range of 40 deaths per year. Not mentioned is that the IOM report, in its Executive Summary, page 11, said, "Using all the resources noted above, the committee was unable to find a substantial body of direct evidence that established the existence of a definite human hazard in the use of subtherapeutic concentrations of penicillin and tetracyclines in animal feeds."

   This leads to recommendations by the committee for strengthening the data bases for future risk analyses, and they say that these recommendations "would seem particularly appropriate in view of the fact that debate on the benefits of use of subtherapeutic doses of penicillin and the tetracycline in animal feed has gone on for over two decades."

   The IOM report also says that "eliminating subtherapeutic uses of these antibiotics may not have a significant effect on the model estimate of salmonellosis mortality since drug-susceptible salmonellae can also cause illness and death."

   The caution displayed by the IOM committee is not reflected in the blunt statements in the book.

4. **Organic foods.** The book gives "case studies" of farms that produce organic or natural foods, such as organic rice.

   While we admire the continuing effort made by farmers, their collaborators, and their scientific advisors to upgrade agriculture, we cannot include the organic industry in this. It is appropriate, once again, to recall its history and its mythological beliefs.

   The term organic as popularly applied to foods was foisted on the public by a steady barrage of publicity initiated by the Rodale Press (Jukes, 1977). The founder and first owner of the Rodale Press was Jerome I. Rodale, a native of New York City. He was without formal scientific training, and he started in business as an electrical contractor. He moved to Pennsylvania, where he became interested in a form of gardening and farming that emphasized the application of animal and vegetable residues to the soil. This practice is, of course, as old as agriculture itself, but Rodale claimed that his procedure was distinctive in that it excluded the use of so-called "chemical fertilizers." His next step was to promote the illusion that crops raised by his "organic gardening" procedure were, in some mysterious and undefinable way, different from crops raised by conventional procedures. This postulation led to his introducing the term "organically produced food," which was shortened for convenience to "organic food." The terms "organic food," "organic gardening," and "organic farming" are now glibly used, without definition, by the media.

   A definition of organic used in proposed legislation was: (1) the term "organically grown food" means food which has not been subjected to pesticides or artificial fertilizers and which has been grown in soil whose humus content is increased by the addition of organic matter.

An article in *Prevention* magazine stated that the difference between a synthetic vitamin and a "natural vitamin" was like the difference between a photograph and a "living, breathing, laughing child." Two other fables fostered by the organic food literature are a story that fertile eggs are in some way nutritionally superior to infertile eggs, and the advocacy of raw milk as being superior to pasteurized milk.

"Organic" rice is indistinguishable from regular rice, according to analyses carried out by the California Department of Agriculture.

Literature Cited

Ames, B. N. 1979. Identifying environmental carcinogens causing mutations and cancer. *Science* 204:587-593.

Ames, B. N., R. Magaw, and L. S. Gold. 1987. Ranking possible carcinogenic hazards. *Science* 237:271-280.

Ames, B. N. 1989. What are the major carcinogens in the etiology of human cancer? Pp. 237-247. In V. T. deVita, Jr., S. Hellman, S. A. Rosenberg (Eds.). *Important advances in oncology*. J. B. Lippincott, Philadelphia, Pennsylvania.

Astwood, E. B. 1945. Chemotherapy of hyperthyroidism. *Harvey Lectures* 40:195-235.

Axelrod, A. and C. P. Leblond. 1954. *Proc. Am. Assoc. Cancer Res.* 1:2.

Foster, E. M. 1990. Food safety, a look to the future. Food Research Institute, University of Wisconsin. Manuscript in preparation.

Goodman, A. G. and F. Murad. 1975. Thyroid and antithyroid drugs. Pp. 1398-1422. In L. S. Goodman and A. Gilman (Eds.). *Pharmacological Basis of Therapeutics*, 5th Edition. Macmillan Publishing Co., New York, N.Y.

Griesbach, W. E. 1941. *Brit. J. Exptl. Pathol.* 22:245.

Griesbach, W. E., T. H. Kennedy, and H. D. Purves. 1945. *Brit. J. Exptl. Pathol.* 26:18.

Jukes, T. H. 1977. Organic food. *CRC Crit. Rev. Sci. Nutr.* 9:395-418. CRC Press, Boca Raton, Florida.

Tarr, H. L. A. 1984. Antibiotics as food preservatives. Pp. 109-125. In J. H. Steele and G. H. Beran (Eds.). *Handbook series in zoonoses*, Section D, Vol. 1. CRC Press, Boca Raton, Florida.

Commentary on the National Research Council Publication, *Alternative Agriculture*

Robert C. Lanphier, III
President and Chairman
AGMED Inc.
Springfield, Illinois

SUMMARY

This study needs to be viewed in the context within which it has been written, not treated as a comprehensive statement on a complex subject that is beset with misinterpretations and economic, social, environmental, and certainly political overtones.

In lacking a comprehensiveness, the study focused on a relatively small number of sites and circumstances, which can hardly be termed as typical of the status. These need to be interpreted as examples within the whole, rather than a sampling of the whole.

Any method of evaluation needs to consider the overall impact of all approaches and judgements on sustainable agriculture, a "farming systems" perspective.

REVIEW

The study, *Alternative Agriculture* by the National Research Council, needs to be taken in the context within which it has been written, not treated as a comprehensive statement on a complex subject that is beset with misinterpretations and economic, cultural, social, environmental, and certainly political overtones.

In lacking a comprehensiveness, the study focused on a relatively small number of sites and circumstances, which can hardly be termed as typical of the status. These need to be interpreted as examples within the whole, rather than a sampling of the whole.

The Equipment Manufacturer's Institute represents 90% of the farm equipment sold in this country, and recognizes that "sustainability has long been a goal of production agriculture." On October 10, 1989, the EMI Board of Directors adopted the following position statement on sustainable agriculture:

> "A sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs, is economically viable, and enhances the quality of life for farmers and society as a whole.
>
> "This definition implies efficient use of purchased and natural resources, continued profitability and minimal adverse effect on the environment.
>
> "The concept of a sustainable agriculture as defined above is complimentary to other major movements in agriculture: soil conservation, energy conservation, ground water quality, improved water management, integrated pest management, and maximum economic production levels.

"The broad line of tillage and planting equipment available for conservation tillage practices is evidence of how industry has responded to new needs in agriculture. The farm equipment industry will continue to develop and provide improved and more efficient methods of mechanizing food and fiber production. Continuing challenges presented by the concepts of sustainable agriculture include:

"Targeted application of plant nutrients by banding and split application.

"Precise placement of pesticides.

"Mechanical tillage alternatives to chemical weed and pest control.

"Tillage practices that help conserve soil and water.

"Equipment to support crop rotation, intercropping, and a wide range of farming practices.

"In most cases, equipment is already available to support the concept of a sustainable agriculture. As with conservation tillage, the responsibility for prudent use of machinery, pesticides, fertilizer, and other inputs rests with the farmer.

"We have serious reservations about the positions of special interest groups who advocate total elimination of pesticides and inorganic fertilizers. This approach may be appropriate for some farmers, but not for the majority of North American production agriculture. An ample supply of low-cost, high-quality food is still a high agenda item for our society. Extreme ecosystems may be counter productive and must be carefully studied before implemented on a wide-scale basis."

This Equipment Manufacturers Institute policy strongly encourages the "Farming Systems" approach to determining the overall impact of all approaches and judgements on sustainable agriculture.

The question of:

"How fast and how far this transformation of U.S. agriculture will go depends on economic opportunities and incentives, which are shaped by farm policies, market forces, research priorities, and the importance society places on achieving environmental goals."

as addressed in the *Alternative Agriculture* study is worth repeating:

"Ultimately, farmers will be the ones to decide. However, significant adoption of alternative practices will not occur until economic incentives change. This change will require fundamental reforms in agricultural programs and policies. Regulatory policy may play a role, particularly in raising the cost of conventional practices to reflect more closely their full social and environmental costs. On-farm research will have to be increased and directed toward systems that achieve the multiple goals of profitability, continued productivity, and environmental safety. Farmers will also have to acquire the new knowledge and management skills necessary to implement successful alternative practices. If these conditions are met, today's alternative farming practices could become tomorrow's conventional practices, with significant benefits for farmers, the economy, and the environment."

Review of *Alternative Agriculture*

Gary D. Osweiler
College of Veterinary Medicine
Iowa State University

SUMMARY

Overall, this is a very good publication, well written and easy to read for those not experienced in the wide range of technical expertise involved in agriculture.

Generally, it is heavily oriented to crop production agriculture and the best and most specific examples are in that area.

Since much of the impetus for alternative agriculture is based on real or perceived adverse health effects of agricultural practices, some increased attention could have been focused on the degree of risk posed by certain environmental pollutants or food chemical residues. Since not all pollutants can be reduced with equal ease or speed, some attention should be given to prioritizing risks from various pollutants.

The report pointed out nicely the potential farm impact of increased forage utilization and increased use of livestock. However, only brief mention was made of the aggregate economic effects of increased livestock production on a national or world wide basis. If livestock were widely increased as an alternative to crop production, could markets and the economy absorb this production before such operations became economically non-viable to individual producers?

This publication provides a great deal of information and some thought-provoking scenarios for consideration by producers, government, and the public.

REVIEW

Overall, this is a very good publication, well written, and easy to read for those not experienced in the wide range of technical expertise involved in agriculture. Clear and concise explanations of current practice are followed by discussion of current problems, possible alternatives, and potential benefits or risks of such alternatives.

Generally, it is heavily oriented to crop production agriculture, and the best and most specific examples are in that area. Explanations and examples of animal agriculture are generally more brief and less well developed with specific data.

Since much of the impetus for alternative agriculture is based on real or perceived adverse health effects of agricultural practices, some increased attention could have been focused on the degree of risk posed by certain environmental pollutants or food chemical residues. Since not all pollutants can be reduced with equal ease or speed, some attention should be given to prioritizing risks from various pollutants. Mere presence of a pollutant may be undesirable, but if removal creates a substantial economic impact, then a serious review of probability for harm should be undertaken. For example, nitrate in drinking water is often cited as an adverse health risk from agricultural pollution. However, the contribution of polluted well water to total nitrate exposure appeared not to be discussed. A statement that "prolonged exposure to nitrate levels exceeding this standard can lead to methemoglobinemia "may, in fact, mislead the public. This is because the standard is set for infants with regard to methemoglobinemia. Dangerous levels are well above 10 mg/liter. Furthermore, additional evidence would suggest other sources for nitrate in infants.

The report pointed out nicely the potential on-farm impact of increased forage utilization and increased use of livestock. However, only brief mention was made of the aggregate economic effects of increased livestock production on a national or worldwide basis. If livestock were widely increased as an alternative to crop production, could markets and the economy absorb this production before such operations became economically nonviable to individual producers? If this is an economic risk, or if it is an unknown, it would be useful perspective.

Some mention was made that greater concentrations of livestock in confinement increase the use of antibiotics and thus the potential for residues. In fact, highly concentrated and well managed integrated units such as intensive beef feedlots and poultry have less residue problems than do smaller and more independent operations. This is generally believed to be due to the high degree of management and quality control used in intensive animal operations.

This publication provides a great deal of information and some thought-provoking scenarios for consideration by producers, government, and the public. Hopefully, the areas less well developed will be the focus of increased attention by modelling and research activities in the future.

Comments on the National Research Council Study, *Alternative Agriculture*

John N. Walker
Professor, Department of Agricultural Engineering
University of Kentucky

SUMMARY

In *Alternative Agriculture*, the authors clearly attempted to be comprehensive and to base their conclusions on evidence in authoritative sources. The organization of the report is excellent. No major issues were identified which were not covered in the report.

The committee is also to be commended on developing a specific definition of "alternative agriculture." The definition is comprehensive and one that should be endorsed by all interest groups.

The conclusions in the Executive Summary are appropriate and generally well stated.

The body of the report, however, does not maintain the same degree of objectivity. In a number of cases, the reader is led to believe that some of the alternative practices discussed are proven viable practices which can or should be adopted on a wide scale. The report takes a number of low input practices and considers them on a single farm basis with current market conditions and shows a positive economic impact. In the Executive Summary, the point is made that the total system needs to be analyzed to determine the impacts and potential of adoption of alternative practices.

The Executive Summary goes further, to say that the Research/Extension sector has not developed the information and procedures to allow this to be accomplished.

REVIEW

The book, *Alternative Agriculture*, is a major report on a very complex issue. The authors clearly attempted to be comprehensive and to base their conclusions on evidence in authoritative sources. The organization of the report is excellent and logical. I did not identify any major issues which were not covered in the report. Though I would commend the authors for their thoroughness, the report appears to straddle the fence on many key issues with an attempt to appease the "alternate agriculture" (low or zero input) advocates, as well as the large commercial producer and his input suppliers.

The committee is also to be commended on developing a specific definition of "alternative agriculture." The definition is comprehensive and one that should be endorsed by virtually all interest groups. Hopefully, all components of the industry will use "alternative agriculture" in place of "sustainable agriculture," "low input agriculture," organic agriculture, etc. Those sectors that chose to use these latter words should clearly define these terms and how they differ from "alternative agriculture."

The conclusions drawn by the committee in the Executive Summary appear appropriate and generally well stated. I personally question if, as indicated in the second conclusion, many farmers have adopted alternative agriculture practices to "protect . . . their communities from the potential hazards of agricultural chemicals." This is particularly true for the part time and the small family farmer, where financial returns are small and, hence, the resources necessary for adopting conservation and other alternative practices are limited. These groups of farmers are clearly interested in reducing input costs and thereby conserving capital. Some of these farmers, in order to increase income, take advantage of niche markets that are quite inelastic, including organic or zero chemical use production. The primary incentive for the producers who exploit such markets, I would argue, is in fact economic. With this one reservation, the conclusions all appear well stated and noncontroversial.

The body of the report, however, does not maintain the same degree of objectivity as in the Executive Summary. In a number of cases, the reader is led to believe that some of the alternative practices discussed are proven viable practices which can or should be adopted. This contrasts to the Executive Summary, where the point is made that the total system needs to be analyzed to determine the impacts and potential of adoption of alternative practices. The Executive Summary goes further, to say that the

Research/Extension sector has not developed the information and procedures to allow this to be accomplished.

In spite of this statement in the Executive Summary, the report takes a number of low input practices and considers them on a single farm basis with current market conditions and shows a positive economic impact. It also appears to generally accept biological materials as inherently nonpolluting and purchased chemicals as environmentally harmful. Clearly, animal manures have a high pollution potential, and their increased use as a plant nutrient source will almost assuredly increase coliform contamination of underground water supplies. These materials also may have a pollution potential which may be greater than that with commercial fertilizer, depending on the nutrient management practices employed. I also question if the average consumer will accept claims that biological agents used to control pests pose low or zero risk when they have been unwilling to accept similar assurances relative to chemical agents.

Secondly, the report never deals effectively with the impact of a major change in crop rotation and other practices by a significant percentage of the farms. For instance, in the "Economic Evaluation" chapter, a rotation of spring peas, medic, medic, wheat is suggested. In another place, barley or oats are a regular part of the rotation. The report indicates farmers with these rotations have comparatively low input cost and a high return per unit of production. No discussion, however, is presented as to what would happen to the price of oats, barley, medic, or spring peas if these crops were grown on large acreages. The Executive Summary indicates total system assessments are necessary to make such determinations, but this is not what is said in this chapter.

Third, the report recommends in virtually all scenarios, a major emphasis on legumes, either for their nitrogen fixing or soil holding capabilities. Increased legumes usage may increase nitrogen movement into the groundwater if not totally utilized by plant material. The variations in background groundwater nitrogen have been linked to natural legume growth on the overlying soils. Increased use of legumes will also require a major expansion of ruminant agriculture with a resulting major expansion of manure production, which in turn will result in a significant increased pollution potential. This linkage is not effectively addressed. Currently, water quality regulatory activity is being proposed to limit the amount of manure that can be placed on land, the manner and time when it is placed on the land, and the buffer zones near waterways where no manure can be used. There are also studies and reports indicating that for a more healthful diet, red meat consumption should be reduced. The report does not address the health implications of an expanded red meat supply which would result from widespread adoption of the proposed alternative agriculture practices.

In summary, I support the statements, conclusions, and recommendations in the Executive Summary, but feel the body of the report lacks objectivity in some areas.

Alternative Agriculture: Its Potential Impact on Nutrition and Health

Karen K. Wilken and Patricia A. Kendall
Department of Food Science and Human Nutrition
Colorado State University

SUMMARY

The National Research Council (NRC) report *Alternative Agriculture* addresses concerns that have been expressed by both the nutrition community and consumers. While it presents the case that alternative production practices and concomitant shifts in agricultural policies would benefit the agricultural community and the environment, we feel the benefits could extend to nutrition, health, and consumer perceptions of the U. S. food system as well. The report's conclusions point toward greater integration of agricultural policy with food and nutrition policy. It's cursory attention to the effect of alternative production practices on food prices draws attention to the need for research in this important area.

REVIEW

We have examined the potential impact of the National Research Council (NRC) report, *Alternative Agriculture*, from two points of view: as nutritionists interested in furthering the U.S. Department of Agriculture's Dietary Guidelines for Americans, and as food scientists interested in insuring a safe food supply from both microbial and residue points of view.

Our purpose is to examine the nutritional implications of this report and to consider its potential impact on food and agricultural policy. Others are examining its agricultural and economic assumptions. In the past few years, nutritionists, food scientists, and consumers have expressed concerns about various aspects of the U.S. agricultural system. Many of the findings and recommendations in *Alternative Agriculture* address these concerns. We therefore find it a valuable and stimulating document.

Nutritional Issues

One of the USDA Dietary Guidelines reads, "Avoid too much fat, saturated fat, and cholesterol." The NRC report highlights the dichotomy between agricultural policy and food/nutrition policy by stating, "meat and dairy grading standards continue to provide economic incentives for high-fat content, even though considerable evidence supports the relationship between high consumption of fats and chronic diseases, particularly heart disease" (page 12).

Federal meat grading standards have traditionally equated high fat content with high quality. The report states that, "recent changes in grading standards have opened new markets for leaner products, but full adoption of research results is still hindered by economic incentives" (page 167). As the 1988 NRC report, *Designing Foods*, also points out, the health of the nation will benefit if these incentives are examined and agricultural policy is adjusted to reflect current knowledge on the relationship between nutrition and health.

While the beef industry is adjusting to a lower fat profile, the dairy industry has not responded as quickly. *Alternative Agriculture* states "the USDA grading standards and milk pricing standards reward producers for butterfat content of milk. Since the 1940s, however, butterfat consumption has declined dramatically. . . . Consequently, the butterfat-based pricing system has resulted in large government-held surpluses of butter, despite the capability of producers—through genetics and management—to produce lower fat products" (page 84).

A final nutritional consideration relates crop rotations to the first Dietary Guideline, "Eat a variety of foods," which is the mainstay of insuring adequate nutrient intakes. A high percentage of foods available in the United States are based on two grains, wheat and corn. Broadening that base to include more grains has positive nutritional ramifications.

While the report details the many agricultural benefits of crop rotation, we suggest possible nutritional benefits as well. Increasing crop rotation practices would lead to greater diversity in crops, since not only legumes, but also rye, barley, buckwheat, and oats are commonly used in rotations. This could in turn lead to greater variety in basic foods available to the consumer, creating a broader food base for meeting nutrient needs. While somewhat speculative, this idea has enough merit to be considered along with other factors in establishing federal policies that encourage crop rotations.

Food Safety Issues

As stated in the report, "food-borne illness is a significant health problem in the U.S., causing an estimated 33 million human illnesses and 9,000 human deaths each year" (page 127). If major reductions in the incidence of food-borne illness are to be made, all sectors of the food chain from production through processing and consumption must evaluate their systems and take steps to reduce microbial contamination.

It is well documented that certain slaughter practices result in a high prevalence of microbiological contamination. For example, in an NRC study, one-third of all poultry sold was contaminated with *Salmonella* spp. We agree with the NRC report that research is needed to evaluate production, slaughter, and processing systems, and that practices producing food with fewer inherent risks need to be promoted. This, coupled with more effective eduction of food service workers and consumers regarding safe preparation, handling, and storage of food will go far in reducing the incidence of food-borne illness.

Chemical residues are another concern of consumers and producers addressed in the report. As pointed out, "two major problems facing policymakers attempting to regulate pesticides are the lack of data on the [health] hazards of pesticides and a lack of accurate exposure data" (page 126). We agree with the position taken in the report that, based on available data, pesticide residues do not make a major contribution to the overall risk of cancer for humans, but the risks they pose may not be insignificant and, in most cases, can be substantially reduced.

Pesticide exposure is not limited to food consumption. Water and airborne pesticides add to exposure and will be higher for those living adjacent to farms where pesticides are heavily used. Agricultural workers are particularly at risk.

The NRC report discusses several practices, from adjustment of cosmetic standards for fruits and vegetables to enhanced use of integrated pest management, for their potential in reducing overall pesticide exposure. From a food safety and health point of view, we encourage further examination and adoption of such practices.

Food Prices

Food prices have nutritional ramifications, especially among the poor; unfortunately the report gives only cursory attention to the important question of how alternative production practices will affect food prices. The only direct reference we find is that "research should be expanded on consumer attitudes toward paying slightly higher prices for foods with lower or no pesticide residues. . . . " (page 23). This shows a narrow view of the full impact that low chemical/high diversity cropping may have on food prices, since residue-free foods is but one issue. There are likely to be shifts in prices of foods such as oils, sweeteners, and meats that are based on such field crops as corn and soybeans.

Changes toward low chemical/high diversity cropping will be gradual, if indeed they happen at all. After a period of transition, food prices will ultimately be determined by an interaction of new production systems, trends in consumer food preferences, and government policies. At this time, we can only speculate whether food prices will rise or fall as a cumulative result of these forces.

In summary, the NRC report, *Alternative Agriculture*, addresses concerns that have been expressed by both the nutrition community and consumers. It presents the case that alternative production practices and concomitant shifts in agricultural policies would have far-reaching benefits. We feel the benefits extend to nutrition and health as well as to bolstering consumer confidence in agriculture and the safety of the food supply, but that the effect on food prices is unknown and needs attention.

We applaud the report for raising these issues, and hope that the ensuing debate will result in increased integration of agricultural policy with food and nutrition policy.

5

Animal Sciences

Alternative Agriculture
Twentieth Century (Limited)

Richard E. Bradley
College of Veterinary Medicine
University of Florida

SUMMARY

In summary, the report by the NRC entitled *Alternative Agriculture* should be read and studied by everyone associated with decision making as it affects American agriculture. Its message is both powerful and timely in the effort to better manage our habitat on Planet Earth from this time forward.

REVIEW

This title does not refer to the famous passenger train, but rather the time frame for a globe called Planet Earth that we all ride on. Our entire habitat is in trouble, and we had better be making a lot of changes in how we are managing (or mismanaging) it.

Alternative Agriculture is not a "buzz word," but rather an important concept to be learned or relearned by everyone who lives on Planet Earth. The National Research Council's recent publication by that same name (*Alternative Agriculture*, National Academy Press, Washington, D.C., 1989) directly confronts the issue in an excellent manner, based extensively on case studies that show how reduced pesticide use, for instance, does not significantly reduce crop yields or animal production units. The 11 case studies reported in the publication have been used to help formulate and test hypotheses related to alternative agriculture, and have provided more than anecdotal data to be applied to the diverse American agriculture.

I was especially interested in the Integrated Pest Management (IPM) that was illustrated in the case studies, not just on crop-livestock farms, but also on the fruit-vegetable farms and the two specialty farms. There are distinct advantages to following an IPM program, which is a good example of how a rather controversial program, when first initiated, has become accepted in practice. It presents an alternative to the heavy use of chemicals to control pests.

I was also struck by the successes reported in several of the farming operations that use nitrogen-fixing crops in crop rotation plans as the source of nitrogen for next year's crop. I learned this basic tenet of farming in vocational agriculture courses nearly 50 years ago! It presents an alternative to heavy use of chemical fertilizers that does not reduce crop yields.

A third feature of the NRC report is that the economic yield of the farming practices need not be greatly reduced to the operation(s). For direct consumer contact, "organic" production of vegetables, grains, and livestock products commands attention and, generally, a premium price. The indirect benefit of alternative agriculture methods is a significant reduction in the cost of producing a crop. This is in the face of often increased labor costs brought about by more cultivation of crops to control weed growth, for instance.

In summary, the report by the NRC entitled *Alternative Agriculture* should be read and studied by everyone associated with decision making as it affects American agriculture. Its message is both powerful and timely in the effort to better manage our habitat on Planet Earth from this time forward.

Review of *Alternative Agriculture*

Virgil W. Hays
Professor, Department of Animal Sciences
University of Kentucky

SUMMARY

The committee report entitled *Alternative Agriculture* has focused attention on some of the real and/or perceived production, environmental, and policy issues related to agriculture. The animal aspects of the report, particularly those related to specialization, confinement rearing, waste management, and animal health, could have been strengthened greatly by use of the expertise and reports of other task forces having done in-depth studies in these areas. If the report is accepted as challenges to producers, researchers, and policymakers, it will serve a very useful function. However, should the report be interpreted as scientifically based models for change, there is substantial

risk of detrimental effects on animal production without significant beneficial effects on the environment. Unfortunately, the media reports suggest that some are viewing selected statements and the case studies as models for change.

A very positive element of the report is the emphasis on need for systems research, an area that has been neglected in recent years. The elements of the case studies presented or any other alternative practices must be evaluated as to whether or not they will contribute to environmental improvement as well as to their practicality on a regional, national, or global scale.

REVIEW

Agriculture and the Economy

This chapter is a factual description of trends and current conditions in U.S. agriculture that encourage chemically-based farming practices and maximum yield objectives. A wealth of data and information are provided, making the chapter valuable for more than its intended use.

The definition of alternative agriculture in the box on page 27 is presumably attributable to the authors. It seems sound, but it would be useful to compare it with others. Likewise, it would be useful to have the authors' definition of conventional farming.

The section on the "power of policy" is justifiably critical of federal farm programs as discouraging the adoption of alternative agriculture practices. But the example provided to illustrate how deficiency payments lead to expanded production is not valid (page 70). The example asserts that a farmer with a 500-acre crop base will expand production if the target price is set above the market price. Deficiency payment programs invariably require set-asides (idling part of the crop base). While participants may expand production on eligible acreage, the expansion would have to exceed production lost on idled acres to cause a net increase in production. That is unlikely, especially in light of the large set-aside requirements in recent programs. Most analysts have concluded that deficiency payment programs have reduced production levels under what they would have been in the absence of the programs.

In other words, while there is no question that high target prices have encouraged the use of yield-maximizing production practices on eligible acreage, it is incorrect to state that farm programs are responsible for surplus production. To the contrary, they have checked excess productive capacity.

There are a few other questionable areas, including:

1. It is asserted that the Dairy Termination Program (DTP) caused a steep decline in hay prices (page 68) because DTP participants continued to produce and sell hay. That was likely a minor factor in any hay price reduction compared to eligible haying on the large set-aside in 1986 and other factors.

2. In the definition of terms used in commodity programs (pages 74 and 75), it is asserted that USDA sets prices equivalent to target prices and loan

rates for milk. The dairy price support program shares nothing in common with target price-deficiency payment programs used for crops.

Problems in U.S. Agriculture

Like Chapter 1, this chapter is descriptive and, for the most part, factual. It identifies problems associated with the chemically based, yield-oriented farming practices identified and discussed in Chapter 1.

The reader is barraged with tabular material, text, and graphics portraying the scope of water and food contamination with agricultural chemicals. In contrast, there is little dealing with the risks associated with the levels of these chemicals that are present in water and food.

The section on genetic diversity seems unnecessary and/or out of place. The reader is not persuaded that the dominance of Holsteins in the U.S. milking herd represents a serious problem. And if it does, then how will adoption of alternative agriculture rectify the situation? The problem of maintaining a diverse genetic base is a separate issue.

In illustrating genetic uniformity, it is noted that 6 to 7 million dairy cows are bred in the United States each year. There are about 10.2 million cows in the U.S. dairy herd and another 4.5 million dairy heifers. Are only half of these being bred?

Economic Evaluation of Alternative Farming Systems

This chapter is weak; perhaps justifiably given the admitted absence of a consistent empirical database on the profitability of alternative agricultural methods.

The reader is immediately made suspect when the "Several economic analyses of alternative farming systems (that were) conducted in the 1970s are deemed to be flawed" (page 195). Suspicion mounts when the profitability of rotations is later supported by studies done in the 1930 to 1950 period. Supply, demand, cost of input, etc., are not the same today as they were in the 1970s. Likewise, they are not the same as the 1930 to 1950 time period either; nor will they be the same in 2010.

The list of ways that economic performance can be improved (page 195) is redundant. Profitability is and will continue to be the measure of performance at the individual farm level. There are relatively few farmers that do not need an economic incentive to continue in agriculture.

There is a theme running throughout the chapter that lower commodity prices and higher costs for purchased inputs will encourage adoption of alternative agriculture. The justification for this line of reasoning seems to be counter factual—high commodity prices and low input costs lead to yield-oriented, chemically-based farming. If the converse is, indeed, true, then a more reasoned argument must be made.

Some specific comments:

1. The implication from comparing low- and high-income farms in the Kansas and Minnesota farm management data set is that high-income farmers use practices more consistent with alternative agriculture. The only interpretation from these data is that low-income farmers have

paint and metal disease (overcapitalized), do not like to scout for pests or have soil tests done, so they overapply chemicals; and, in the Kansas case, a flat operator fee is spread over half as many acres.

2. It is noted that policy reforms would encourage alternative agriculture (page 207). There is no discussion of the nature of these reforms or how they might be brought about. Guidelines would be useful.

3. IPM is characterized as an alternative agriculture method. It is a common sense approach to pest management that has been broadly accepted. In addition, it is a coined term to describe what many good managers were doing all along. Is it alternative agriculture?

4. It is noted on page 217 that broadleaf weed infestation is greater under ridge-tillage methods that incorporate herbicides than in those where no herbicide is used. An explanation of this peculiar result seems in order. The previous paragraph states that conventional tillage without herbicides has resulted in increased weed infestation.

5. The authors ask for the EPA to calculate economic benefits associated with forbidding chemical uses in reference to IPM strategies (page 218). This would not appear to be realistic in light of the fact that IPM may employ the very chemical for which a ban is being considered.

6. Selection of pest-resistant cultivars is considered (pages 220, 223) a risk-free biological control method. For food crops, how often is the resulting biological change in the plant evaluated as to its safety to the consumer? Naturally occurring pesticides are not necessarily benign.

7. In discussing a case study use of alternative agricultural practices in vineyards (page 223), it is noted that the methods are profitable, but nobody knows why. This is not very instructive.

8. There is a serious and unsubstantiated allegation on page 225 that veterinarians, drug companies, and public research institutions are colluding to promote drug treatment rather than animal health maintenance. The paragraph following the allegation refutes it in describing a mastitis control program! The allegation is patently absurd and casts suspicion on other assertions in the report. There has been an increasing emphasis on total herd health and prevention programs, rather than treating sick animals.

9. Generalizations about the increase in poultry and livestock confinement being correlated with and dependent on subtherapeutic antibiotics (pages 9, 168, 171, and elsewhere) overemphasize the role they have played. Antibiotics are just one of many technologies, including vitamin and mineral fortification of diets, ventilation systems, and mechanization of feed delivery and waste handling, that have continued to evolve along with confinement rearing. In addition, the authors failed to properly consider the environment in which antibiotics are evaluated. Researchers have long recognized that comparisons of animals on different farms, and at different seasons of the year, are not appropriate for conclusions

such as have been drawn in the report, particularly when the observations involved are few in number.

10. In discussing the relative economics of hog confinement versus pasture systems, the report notes that pasture methods provide the highest returns when hog prices are low or feed prices are high (page 227). It would seem that this peculiar result could only occur if return on equity capital and operator and family labor were ignored. All of the data provided are inconsistent with the conclusions drawn. If other costs are fixed within the system, higher feed prices would result in an even higher percentage of total costs being feed costs; hence, favoring the system with more efficient conversion. It is low feed and low labor costs relative to hog prices that contribute to higher profits in the system of high labor and less efficient conversion of feed to pork, as is the case for pasture systems.

11. In discussing poultry production practices, it is noted that alternative systems were profitable, but that a drive for uniformity in vertically integrated poultry and egg industry kept their number few (page 228). What is the uniformity referred to? Uniformity of egg size or bird weight is accomplished by the breeding and management systems used plus sorting of eggs and birds at the processing and packaging level. If the uniformity refers to a high rate of production, the statement is true; and it simply means that the alternative systems have not been competitive.

12. The assertion on page 228 that "today's highly-specialized farms would not be possible without federal program subsidies" is an awfully strong statement that begs for some supporting evidence. Federal farm programs have encouraged specialization, but to say that they would not exist without these programs goes far beyond that. The Federal programs have removed some of the risks associated with certain commodities; but, just as in other production-marketing situations, reduction in risks are accompanied by reduction in economic opportunities. One cannot contend that direct government subsidies of the poultry and swine industries have led to the specialization. More government involvement may be necessary to develop a broad scale trend of diversification. Removal of federal subsidies may put agriculture in the hands of fewer and fewer people.

13. A 1951 study by Heady and Jensen (Iowa State University) is used in defense of the profitability of crop-livestock diversification (page 228). We are no longer in a realm of 15 cows, open-pollinated corn, and 80 acres. More important, the benefits of management specialization are ignored. The proficient herd manager of a 200-cow dairy cannot afford to simultaneously become a proficient crop manager.

14. A 1930s study is used to illustrate the profitability of legumes in a crop rotation (page 231). Again, it is unreasonable to cite such a dated study. More recent studies are available (Klemme).

15. A more recent (1984) rotation study is finally cited (page 232). Unfortunately, the study includes constraints on alfalfa production (for

dairy herd use) that limit its usefulness in evaluating the profitability of legumes in the rotation. What percentage of the farms can justify 60 cows per 400 acres without greatly over producing dairy products? For many acres of land, the legumes in the rotation must be justified on soil fertility value alone and all costs of establishing the legume must be included.

16. It is implied (pages 239 and 240) that changes in federal programs to reduce deficiency payments and make crop bases more flexible would enhance the use of alternative agriculture (presumably expanded legume production). Relative prices drive farm-level decisions, and such changes would sharply modify existing price relationships.

17. In several portions of the report, utilization of animal wastes to offset purchased fertilizers is emphasized. In no place in the book is there a reference to the amount of animal wastes not now being returned to the land. The mineral components of the manure are, for the most part, being returned to land. Certainly, at a cost, a greater effort could be expended to conserve the nitrogen portion of the wastes. Some land at present is overly fertilized. The general tone of the report is that redistribution of animals would correct this.

18. Recognizing that the case studies are not prescriptions for change but indicators that such systems can be successful, another way to look at their successes is to consider that they, too, are being subsidized—by off-farm employment, other nonagriculture support, low rental rate from relatives, under-evaluation of land and/or labor costs, and inflated prices (niche marketing) which works for a few or limited amount of product, but not for all of agriculture production.

General

The publication heavily emphasizes diversification of crops and/or incorporating livestock programs into what has been exclusively cropping systems. Along with this diversification, there is the general recommendation of marked reductions in off-farm inputs. The publication discusses at length the role government policies have played in moving to increased specialization; however, it does not give proper attention to the technological, economic, and sociological forces that have driven American agriculture to increased specialization, increased unit size, and heavier reliance on off-farm inputs such as insecticides, herbicides, and livestock medications. Along with these and other changes has come the sustainability or even reduction in relative food costs and levels of production to more than satisfy the export demand at the existing world price levels.

Technology is increasing at an increasing rate, and no one individual can stay abreast of all the production, purchasing and marketing technologies, and regulatory and governmental policies associated with several crop and animal enterprises combined into one diversified farming system. To be competitive, one must specialize in fewer enterprises or increase the size, acreage, and technical expertise to a level that will support the number of employees necessary for diversification. The report does talk about the competition for labor, which can be serious between and among crop and livestock enterprises. This is well recognized in agriculture circles in that problems in livestock are often referred to as having corn, wheat, or soybean disease, simply indicating the lack of needed attention during critical times of seeding, cultivating, or harvesting.

Socio-economics forces continue to be important contributors to the increases in size and specialization. Livestock enterprises, particularly dairy, poultry, and swine, require attention 365 days of the year. There are fewer and fewer people willing to relegate themselves to a 365-day schedule associated with a family-size, diversified operation. The alternative is to increase size to support at least two or more families or to specialize in cropping in order to allow recreational relief.

Economic pressures are certainly contributing to increased size and specialization. The off-farm employment opportunities, both salary and work schedules, have contributed to the continued migration from agriculture to urban employment. One way to cope with this migration is to have sufficient economic size and specialization to provide social and economic benefits similar to that of off-farm workers.

There is no question that our environment and agriculture production levels must be sustained or improved. However, policies to mandate or incentives to encourage diversification may actually hasten consolidation so that a larger work force (labor and technical expertise) will allow specialization within a larger but diversified unit. Is the public willing to carry the cost of the incentives to encourage diversification, or will we adopt policies that will further endanger the family farm? The individual farmer must provide for the family today, and cannot be expected to live a subsistence and drudgery lifestyle to carry the total burden. The publication properly addresses the real and/or perceived problems and needs, but does not offer, policy "alternatives" for accomplishing diversification.

A very positive element of the report is the expression of a need for renewed emphasis on systems research, a message that is not new to agricultural leaders, research administrators, and the more applied segment of the research community. However, there has been a continued erosion of the support for such research. To have a real impact, research data must be forthcoming so that agriculture will progress, not just be sustained.

The task force preparing *Alternative Agriculture* undertook a Herculean task, and did a remarkable job of addressing many of the production, sociological, and environmental issues facing agriculture. Unfortunately, the book is not being received in a broad sense. As a result, there are risks of overacting to some ideas or proposals and establishing hastily developed "band-aid" policies that will prove costly and ineffective.

Alternative Agriculture
An Animal Scientist's Perspective

William D. Hohenboken
Professor, Department of Animal Science
Virginia Polytechnic Institute and State University

SUMMARY

Livestock have prominent environmental and economical roles in many alternative farming systems, and their incorporation will be critical to the success of other yet-to-be implemented schemes. There also is great potential to incorporate concepts of alternative agriculture on farms whose primary economic activity is livestock production. Livestock grazing systems markedly can enhance environmental quality, and many arid and/or erodible lands are best suited to livestock production. Alternative agricultural philosophies could enhance the fit of livestock to those traditional roles. Livestock populations could undergo successful genetic selection to be healthier, require fewer inputs and be more productive under alternative management schemes.

REVIEW

Synopsis

Livestock have prominent roles in many successful alternative farming systems, and their incorporation will be critical to the success of other yet-to-be implemented schemes. Financial benefits include producing products of high monetary value, enhancing cash flow, and diversifying income generating activities for a farm. Environmental benefits of livestock production can include recycling of nutrients to the soil; utilization of waste products, by-products, and crop residues; reducing cropping system inputs with possible detrimental environmental impact; and allowing an optimum match between agricultural production system and the physical potentials and limitations of the land. In addition, there is great potential (not sufficiently emphasized in the report) to incorporate concepts and goals of alternative agriculture on farms whose primary economic activity is livestock production. Low input and minimal-environmental-impact, sustainable animal production is being accomplished on many farms and ranches. Some livestock grazing systems currently in practice markedly enhance the environment, and others can be developed. Many arid and many erodible lands are best suited to livestock production; alternative agricultural philosophies could enhance the fit of livestock to those traditional roles. Finally, there is evidence that livestock populations could undergo successful genetic selection to be healthier, require fewer inputs, and be more productive under alternative management schemes.

Introduction

Authors of *Alternative Agriculture* have done a commendable job defining the concept, goals, and characteristics of alternative agricultural systems, describing how public policies influence the problems alternative agriculture is meant to solve, surveying scientific understanding and ignorance of alternative systems and examining their economic and environmental consequences. The case studies effectively document what farmer ingenuity, experimentation, adaptation of scientific knowledge, hard work, and creative merchandizing can accomplish. Perhaps readers should have been brought back to earth by presentation of a like number of failures of alternative enterprises. Such cases surely exist.

From an animal scientist perspective, the chapters of *Alternative Agriculture* which precede the case studies underemphasize contributions of animals to past, current, and future American agricultural production. A large proportion of farm income and of consumer expenditures for food are for animals and animal products. The contribution of meat to national export income likely will increase, in dollar value and as a proportion of all agricultural exports. Numerically, animal scientists were not well represented on the committee that authored the report, which may partially account for the scanty coverage which livestock were afforded. In defense of the committee, however, few livestock studies have been published in which one or more of the principles and goals identified for alternative agriculture had a prominent part. Rarer still are interdisciplinary studies of integrated animal production systems, even involving conventional practices. The committee is accurate in their assessment that much of agricultural (including livestock) research is discipline as opposed to system oriented.

Implications of Livestock for Alternative Farming Systems

One goal of alternative agriculture is to "incorporate natural processes" into agricultural production to the greatest feasible extent. Recycling of nutrients is a natural process upon which all sustainable, minimal-input agricultural systems must depend. Grazing animals and their gastrointestinal microflora are efficient recyclers, returning essential nutrients to the soil and simultaneously producing products of high nutritional and monetary value.

A second goal is protection of the environment. Many classes of animals are capable of ingesting and utilizing materials (poultry litter, crop residues, cannery wastes, edible garbage, etc.) which might otherwise be disposed of with detrimental effects on the environment.

A third goal is to more closely match farming systems with the physical characteristics and limitations of agricultural lands. Carefully managed grazing schemes can practically eliminate soil erosion, achieve and maintain and desirable botanical composition of pasture or range, enhance soil fertility with minimal applications of chemical fertilizer, protect watersheds, and conserve wildlife habitat.

A fourth goal of alternative agriculture is to reduce production costs by reducing purchased inputs. The report documents very well the ability to replace some, most, or all purchased fertilizers, on a case-dependent basis, with animal manures. Feeding grain, pasture, and/or hay (but not crop residues) to livestock will reduce the volume of cash crops available for sale, but net income from livestock sales may more than compensate the loss.

A fifth goal is to reduce financial risk through increased enterprise diversification. As noted in the report, adding livestock and/or additional crops to a farming system can increase cash flow, spread labor requirements more evenly throughout the year, and reduce year-to-year variation in farm income.

Implications of Alternative Agricultural Philosophies for Livestock Production Enterprises

As just described, livestock can contribute markedly to efficient alternative farming schemes. The stated philosophies and goals of alternative agriculture also can influence enterprises whose major economic activity is livestock production.

One such philosophy is to rely maximally on "natural processes" in agricultural production. Most farm animals could be produced largely by "natural" methods, because those are the conditions under which their ancestors evolved. (In some instances, such as the inability of turkeys highly selected for breast muscling to perform natural mating, this statement would have to be qualified.) To incorporate natural methods would often reduce monetary costs for an operation, but frequently greater labor and/or management inputs would be required in turn. Often, production per animal unit and per acre would be decreased. The optimum mix of natural versus purchased inputs will be dependent upon costs, effects, and returns and also upon the extent to which some consumers will pay premium prices for "natural" products.

Animal production enterprises can and should be managed to minimize detrimental impacts on the environment or ideally to enhance the environment. This is an area in which considerable research has been conducted (effects of grazing on riparian zones, management of feedlot wastes, cycling of nitrogen, sulfur, and other nutrients to pastures by grazing animals are examples), but in which much more research is needed. With waste disposal a mounting problem, perhaps the role of swine as disposers of municipal garbage should be re-evaluated.

There are vast regions of the country for which livestock constitute the best agricultural fit to the land; and within all regions, carefully managed pastures and grazing animals are best suited to many erodible lands. Interdisciplinary cooperation is needed to design farming systems that will optimize conservation, enhancement, and sustainable financial returns from such lands. Use of unconventional classes of animals (goats for brush and weed control, swine in woodlots) should not be ignored, nor should unconventional management systems, such as agro- or pastoral forestry.

A fourth goal of many alternative agricultural schemes is to reduce purchased inputs. Farmers and research scientists might ask, "What are livestock capable of doing for themselves which currently we attempt to do for them?" Researchers in other countries have been more inclined to ask this question than researchers in the United States. A typical American perspective has been to alter the environment to fit the animal rather than to alter the animal to fit the environment.

In tropical Australia, selection of beef cattle for weight gain created a population with higher resistance to endo- and ectoparasites, heat, and infections of the eye. In Great Britain, sheep indigenous to selenium deficient regions were better able to sequester selenium (an essential trace mineral) from the diet, and within-breed selection for higher tissue concentrations of selenium was successful. In New Zealand, selection for "easy care" sheep has been successful in creating breeds requiring limited human intervention and care at lambing. These results strongly suggest that, given enough effort, we could select "organic" animals, better able to cope with the challenges presented by their particular physical environments.

A fifth goal of alternative agriculture, diversification, offers the same potential benefits to livestock producers as to any agricultural enterprise. It also adds the same costs-greater capital investment for machinery and equipment needed for diverse operations and a greater amount and diversity of management skill. There are sound reasons to expect (and some experimental evidence) that mixed-species production systems reduce problems from host-specific diseases and parasites and allow fuller utilization of available nutritional resources. Again, nontraditional species, even nondomesticated animals, should be considered.

Concluding Comments

As this evaluation is being written, a popular commercial film is a second installment of "Back to the Future." As I read *Alternative Agriculture*, I thought, instead, of "Forward to the Past." The crop rotations, inclusion of livestock, minimal use of chemical inputs (many were not available in the 1940s and 1950s) and diversification that are advocated as viable alternatives in the report characterize quite accurately the Illinois livestock and crop farm on which I was raised. By this, I do not imply a belief that alternative agriculture is regressive. Few, certainly not me, would argue convincingly against the need to preserve the environment, provide safe and economical food and fiber to the consumer, lower production costs, enhance farmer income and bring agricultural production into reasonable balance with national and international demand. Alternative agriculture can help to achieve these goals.

Farmers and their cadre of advisors should be encouraged to learn, adapt, and apply appropriate alternative farming skills. The agricultural research establishment should engage in more interdisciplinary work to aid such adoption, but not to the exclusion of basic, disciplinary research which generates the knowledge base upon which future advances will be made. I would encourage state experiment stations to conduct case studies, within their borders, of the sort published in the report. Research/extension teams should then attempt to define and quantify reasons for commercial successes and failures.

Lessons in effective integration of cropping and livestock systems might also be found in ancient agriculture, either from archeological evidence or from examination of contemporary primitive systems in developing countries. In a manner analogous to the biological evolution of species to fit an ecological niche, farming systems also evolved to fit their agricultural and economic niches. We should be sensitive to any wisdom generated by the trials and errors of our farmer ancestors.

Policymakers should provide the funding, resources, and incentives to make such research possible and to encourage adoption of alternative agricultural practices, when this would be to the mutual benefit of present and future generations of farmers and consumers.

Comments on the National Research Council Publication, *Alternative Agriculture*

J. E. Legates
Wm. Neal Reynolds Professor and Dean, Emeritus
North Carolina State University

SUMMARY

An important contribution is made in focusing upon the fragility of our agricultural resource base. Depletion of soils and forests and contamination of water sources are of vital concern. Farm operators, however, must manage within the constraints of the political, economic, and social system to remain viable even in the short-run. While alternative agricultural practices are desired to sustain our natural resource base, the economic viability of proposed systems has yet to be solidly documented by research or field demonstrations. Such evidence is difficult to obtain. As a consequence, caution must be exercised in setting forth broad recommendations for farm implementation.

REVIEW

The report identifies several environmentally oriented concerns relating to agriculture and impinging upon our natural resource base that also are broadly common to nearly all current economic and social endeavors. Garbage and human waste, industrial waste, radioactive waste and residues from nuclear reactors and weapons manufacture, ozone depletion and air pollution, depletion of non-renewable energy resources, and contamination of water supplies are among these imminent societal concerns. Acute problems in each of these areas have been intensified by the increase and concentration of our population. For each of these situations, cogent societal redirection is urgent to preserve or renew our resource base.

Taken to the extreme, if the earth were allowed to remain essentially pristine, it would sustain only several million inhabitants surviving on roots, herbs, fruits, nuts, fish, and game. This is not an alternative, as our current growing and concentrated human population has heavy demands for food, clothing, shelter, and other amenities. Depletion of soils and forests and contamination of water sources are real concerns that place our future in jeopardy. The report serves to remind us again of this situation and our responsibility to ameliorate it.

Comments concerning the report will be focused on the four major findings stated on pages 5 and 6. First, the report has provided comprehensive background information regarding U.S. agriculture and the key relevant points of concern. However, the economic viability of an agriculture that adheres to the alternative system is neither documented by research nor demonstrated by recorded field experience. The extensive coverage and dependence on the case studies reflect the paucity of solid factual information regarding the "greater economic benefits" of the alternative system. This renders certain findings and related recommendations more philosophic than scientific.

Second, truthfully, federal policy has made a plentiful "low cost" food supply a higher priority than the protection of our natural resource base. As the report rightfully reflects, government programs with this primary objective erode our resource base. Farm operators, however, must manage within the constraints of the political, economic, and social system to remain viable. High interest rates discourage long-term investment to implement many desired practices. Altruism and personal denial will not provide for the family necessities or pay the mortgage. Resource preservation and renewal should be appealing to anyone with an appreciation of biological cycles and the miracle of natural renewal. However, solid incentives to inaugurate practices and systems that could sustain the farming operation and not jeopardize its solvency are essential. The farming community cannot accomplish this alone. It must become a mandate from our citizenry; one that is difficult to obtain from a well-fed populace.

Third, a systems approach to research is necessary, not on its own, but as a complement to intensive specifically oriented research. The individual components of a system must be identified and understood before they can be appropriately integrated. These research results also must be widely tested in farm situations to provide the basis for solid recommendations. Clearly such results are difficult to obtain, and as a consequence caution must be exercised in putting forth weakly founded advice.

Systems research requires experienced persons who can synthesize ideas and who have the ability to engender the support of collaborators. Funding requirements for such broad efforts are considerable and beyond the availability of most individual researchers: hence, most scientists tackle only a specific component of the question. The syntheses of these findings into a practical system that is biologically and economically sustainable is difficult and costly. Nevertheless, most farmers will not and cannot afford to accept dogma. Practices must have demonstrated performance under conditions the farmer can afford to provide.

Fourth, innovative farmers indeed already utilize many "alternative" farming practices. Thus, as acknowledged, conventional agricultural systems include components of alternative agriculture that have demonstrated their value and viability. All current agricultural practices are not to be denounced and alternatives sought. In this content, the term "alternative" is an unfortunate choice. The terminology of a sustainable agriculture is already recognizable and would appear to have been a wiser choice. It could embrace those current practices that are desirable without the potential implications that alternatives are needed for all conventional practices.

The diversification of enterprises which is encouraged in the alternative system calls for more astute managerial skills. Rapid advances in technology requires specialists for each enterprise to remain competitive and productive. If animal and plant enterprises are to be integrated, extremely talented managerial skills are demanded, or large scale operations that can support coordinators for each animal and plant sector could be desirable. In either case, as the report relates, more managemental skill per unit of production is required. The alternative system, then, must provide for increased yield per unit of input and/or markedly reduced production cost per unit of output to reward the superior managemental inputs. Can experience demonstrate that these rewards can accrue to management under the alternative system?

The plea for diversity also appeared to go beyond the limit of our knowledge and experience in certain specific details. What evidence is there that sudden widespread economic loss from disease is imminent from the decreasing genetic diversity of our dairy cattle? Experiences with southern corn leaf blight and rust in cereals are not directly translatable to animal populations. For cattle, presumable foot-and-mouth disease would be one of the most devastating. Beyond the prior question, where is the source of natural genetic resistance to this disease? If available, how could it be utilized readily to decrease potential sudden widespread economic loss from the disease?

Finally, the report represents another desired effort to focus attention on the fragility of our agricultural resource base. This is a need that is in common with other sectors of our society's exploitative activities. The report could have made less pronouncements and emphasized more the rudimentary state of scientifically validated knowledge in the area. Such an acknowledgement could have strengthened and highlighted even more the urgent need for systems research and demonstrated results. The report will serve as a stimulus to further discussions of this important concern, but it is unlikely that it will motivate a rapid implementation of alternative agriculture at the farm level.

Comments on *Alternative Agriculture*

Leon H. Russell
Department of Veterinary Public Health
College of Veterinary Medicine
Texas A&M University

SUMMARY

Comments were focused on those sections dealing with animal health and food safety. The perceived hazards of antibiotic and other drug residues in foods or animal origin were based on some faulty concepts and incorrect interpretations of the current practice of veterinary medicine in the United States. Especially glaring were some outdated beliefs of current animal health preventive medicine programs as they relate to modern livestock management systems.

REVIEW

This review has been prepared at the request of the Council of Agricultural Science and Technology (CAST). This reviewer is a representative to CAST from the American Veterinary Medical Association (AVMA). The opinions expressed are entirely my personal opinions, and do not necessarily reflect the position of Texas A&M University, the AVMA, or CAST.

The report is quite comprehensive and well presented by the National Research Council (NRC). However, just as the committee was not well qualified to deliberate on animal health systems, I am not qualified to comment on those portions of the document dealing with cropping systems. My comments will be directed toward those portions of the report concerning animal health systems and the interrelated area of food safety.

Part One

The Executive Summary is well stated, and should be applauded for the five goals stated on page 4. The development of pest and disease resistant livestock is laudable, but unrealistic with current scientific and economic restraints. The recommendations to diversify animal production, on the basis that concentrated animal production is unhealthy, is contrary to present day management practices which successfully supports livestock health and animal welfare.

Section 2, "Problems in U.S. Agriculture," has some errors which seriously affect the credibility of the document.

1. On page 128, the statement, "Holmberg et al. (1984), however, demonstrated that antibiotic-resistant salmonella caused disease in humans who consumed meat from animals harboring salmonella" perpetuates a distortion contained in that report because, in that study, *Salmonella* spp. were never isolated from the meat and the outbreak was only loosely associated with the suspected beef through the memory of the patients having consumed some "ground beef" within two weeks prior to onset of illness.

2. On page 129, references were made to chloramphenicol residues in food animals. It should have been stated that chloramphenicol was banned for use in food animals in 1984, and has not been recognized as a problem by the Food and Drug Administration since 1986.

3. On page 130, it was stated that "gentamicin. . . . legally available only through veterinarians" is in error. Gentamicin over-the-counter products are advertised in most livestock production publications and are readily available for purchase by anyone today.

4. It remains to be seen whether or not the American consumer will accept lower quality products that will result from the pesticide-free and chemical-free alternatives recommended in this section of the publication.

Section 3, "Research and Science," has some faulty concepts of the current veterinary medical education and veterinary medical practices. Again, there are some statements that seriously damage the credibility of this document.

1. On pages 167 and 168, the statement, "Disease prevention through management has become increasingly an important research objective" is correct; however, the statements, "Nonetheless technologies for disease treatment rather than management systems for disease prevention dominate current animal health systems," and "The subtherapeutic feeding of antibiotics and antibiotic treatment of diseased animals remain the mainstay of current animal health practices," completely ignore the commonly practiced herd health programs of veterinary medicine, modern livestock management, and the trends in veterinary medical and animal science education.

2. On page 171, "Veterinary and medicine costs stemming from swine confinement production systems have been shown to be at least double those of a comparably productive pasture and hutch system," ignores the repeated demonstration that well run confinement systems utilize good preventive medicine practices that result in diminished disease incidence and lowered veterinary medical costs.

Section 4, "Economic Evaluation of Alternative Farming Systems," on page 225 states "Veterinarians, universities, drug companies, and regulatory agencies generally address animal health by treating infected herds or animals primarily with prophylactic feeding of and therapeutic treatment with antibiotics." and "Veterinarians who are able to charge clients for their treatment services, and public and private research reinforce this approach to animal health." These are totally false statements that are an affront to current emphasis in veterinary medical education and private veterinary medical practice.

Part Two

"The Case Studies" should set role models for alternative agricultural systems. However, "Case Study 5, The Thompson Farm" uses animal control methods that could set animal disease control back decades. On page 322, it is mentioned that the livestock receive no vaccinations and are given "distomaceous" [*sic*] earth to control internal parasites. These animals would have a very high risk for exposure to numerous soilborne pathogens, which could result in devastating losses from animal disease and deaths. This could be a model for animal disease disaster in the shadows of one of the world's leading veterinary schools at Iowa State University.

Conclusion

I firmly believe that this document, as a reference upon which to base national legislation, would do irreparable damage to the livestock industry without improving either the economics of the farm population or providing a wholesome, safe food supply to the food consuming public in America. It does not escape this reviewer that the current version of this report contains a sufficient amount of false impressions of modern livestock management to raise questions regarding the motives and unscientifically based opinions of the authors.

Some Comments Relative to Animal Agriculture in a Critique of *Alternative Agriculture*

Allen Trenkle
Department of Animal Science
Iowa State University

SUMMARY

The committee on the role of alternative farming methods in modern production agriculture had a good perspective of the potential role of livestock in the total farm enterprise. Available research data comparing different systems of livestock production were not adequate to make a detailed assessment of the economic impact of alternative production systems. Too much emphasis was placed on the use of subtherapeutic levels of antibiotics in livestock production. Conclusions that animals raised in confinement have a greater incidence of disease and are not as productive were made from inadequate data and could be misleading. Intensive rearing of livestock will be a feasible option for some producers in future agriculture production. The report should not be considered a research document, but rather a compilation of options which should be thoroughly evaluated in research and on-farm testing as possibilities for alternative agricultural production systems.

REVIEW

Over the last 50 years, society has had phenomenal expectations of American agriculture to produce high quality, safe, and cheap food in sufficient quantities for domestic consumption as well as assist starving populations. The agricultural sector has responded to this challenge with dramatic increases in capability of producing food. Overall, the U.S. food supply is abundant and safe. However, with over 30 years of intensive agriculture, it is becoming evident that the cost in terms of environment and required inputs may be too great to sustain this level of production. The greater challenge now confronting agriculture is to develop farming systems that are productive and sustainable.

The committee made a broad assessment of the role of agriculture in the economy and summarized some of the problems facing American agriculture. Some research of alternative farming systems and an economic evaluation of some of these alternative systems were discussed. Unfortunately, available research data comparing different systems of livestock production was not adequate to make a detailed assessment of the economic impact of alternative production systems.

The committee seemed very much aware of the uniqueness of each farm, and therefore did not make broad recommendations. Emphasis seemed to be placed on finding the right blend of practices which could benefit from the biological and economic relationships for a farm in a given location. The case studies presented were by-and-large success stories which seem to have found this right blend. It would be advantageous to also have presented case histories and some detailed analyses of farms that have tried alternative practices but have failed. Understanding failure may be more beneficial than knowing the successes for guiding future changes of agriculture in the right direction.

The committee recognized that scientific knowledge, technology, and management skills necessary for widespread adoption of alternative agriculture are not widely available or well defined. However, in much of the discussion, implications were made that certain systems may be superior. Those implications which relate to animal agriculture will be the focus of this discussion.

1. **Alternative agriculture production systems will result in more diversification.** As pointed out in the report, public policy, government programs, and social changes in the agricultural sector have resulted in less diversification on most farms. Changing farming to include more crop rotation along with less commercial fertilizers and chemicals will tend to bring back more diversification. Adding one or more livestock enterprises will contribute to this. The utilization of crop residues and contribution of manure as fertilizer will increase productivity of the farms as indicated. The committee had a good understanding of the potential contribution of animals to a diversified farm. A well diversified farm should be more resilient to fluctuations in prices of commodities, more compatible with the environment, and therefore, more sustainable.

2. **Subtherapeutic use of antibiotics is a major problem in livestock production.** Two problem areas were identified: (a) presence of antibiotics in milk, and (b) development of bacteria resistant to antibiotics which can be transferred to humans. Antibiotics in milk arises from the use of intramammary infusions to control mastitis. If sufficient time does not lapse between treatment and selling milk, antibiotics will be present in the milk. Discontinuing subtherapeutic use of antibiotics or making them prescription drugs will not solve the problem of antibiotics in milk until producers are educated on the significance of proper withdrawal times. There is no scientific evidence that all of the problems of resistance to antibiotics in humans arise because of their subtherapeutic use in animals. There are a few identified cases of such transfer, but this is because of our meat inspection programs which allow past history of most animals to be reconstructed. There is no documentation to assess the extent of the problem which originates with use of over half of the production of antibiotics in humans. If subtherapeutic use of antibiotics is discontinued, but is allowed to be prescribed for use in animals, most of the problems will continue to be present.

3. **There are many alternative systems for disease prevention.** It was indicated several times that this technology was available, but the only

specific example given was using better management to reduce the incidence of mastitis in dairy cows. The point that good management will help reduce disease cannot be argued, but substituting increased use of disinfectants for antibiotics may substitute one problem for another. Most disinfectants are chemicals used in high concentrations which, in all probability, will result in contamination of milk. Milk currently is not monitored for disinfectants. The effects of disinfectants in milk on health of consumers of milk are not known.

4. **Animal production systems that emphasize disease prevention through health maintenance reduce the need for antibiotics.** The recommendations of extension and research personnel have never been to substitute the feeding of antibiotics for good management practices. Most producers of livestock in confinement perceive the use of antibiotics to be a health maintenance practice to prevent serious outbreaks of disease. Other preventive measures such as sanitation, environmental controls, and immunization continue to be practiced on well managed farms using antibiotics.

5. **Animals raised in confinement usually exhibit greater incidence of disease.** This conclusion seems to have been reached from data summarized from swine records indicating that producers using pasture systems spend about half for veterinary care as compared with producers using confinement systems. The sample of producers using the pasture system was eight compared with 22 using confinement. This is not an adequate size of sample to make this conclusion. Producers with large herds in confinement may use a veterinarian more extensively for disease prevention, thereby increasing veterinary costs. There could also be other explanations.

6. **Low confinement systems usually provide the greater return per animal for all types of swine operations.** This conclusion is also based on very limited number of pasture systems, and could be biased by one or two operators. The excellent managers will wean more pigs per sow in confinement compared with pasture which tends to compensate for the increased input for facilities. Many factors need to be considered when deciding a level of confinement to use in a swine production system. Price of land for pasture is one important factor. In colder climates, consideration should be given to farrowing in the winter to distribute the use of labor throughout the year.

7. **Many consumers and businesses are willing to pay a higher price for "chemical-free organic produce."** This is an overstatement. Certainly there are those who are willing to pay more for foods they perceive to be safer, but it is a small percentage of the total. Success for farmers producing for these buyers requires greater input for finding and maintaining these markets. The lack of a market for their produce, which often must be sold at a higher price, is a cause for failure of some individuals who have attempted alternative production systems.

8. **Increase the use of livestock manure as fertilizer.** The committee recognized that farmers have built up the phosphorus content of soils over

the past three decades. Because manure is high in phosphates relative to nitrogen, using enough manure to provide nitrogen may lead to undesirable concentrations of phosphates, as well as potassium and sodium in the soil. A more appropriate and environmentally sound approach may be to use a combination of a chemical source of nitrogen along with manure.

9. **Production of meat with less fat and hormone therapy to modulate disease resistance.** The committee seemed willing to accept the use of porcine somatotropin and prostaglandin $F_{2\alpha}$, two hormones, to increase the muscle-to-fat ratio of pigs and to increase disease resistance, respectively. This seems to be somewhat of a contradiction of the overall theme of the report because these will be two relatively high-cost inputs. Producers in conventional agriculture have been willing to make investments if the returns on those investments were adequate. Somatotropin and prostaglandins are examples of continued development of technology to enhance animal production. Several of the livestock producers presented in the case studies were investing in use of probiotics as a means to maintain animal health. The concept that some organisms may make a positive contribution to the health of animals seems to be feasible, but it has not been possible to confirm monetary returns from this investment in well designed animal experiments.

Data for animal performance were not presented for all the case studies. In those instances where it was, performance was no more than average for other well managed livestock farms. It is futile to use these data to compare production systems because many factors are involved in performance of livestock. There is a need for well designed research to evaluate animal production systems under similar conditions.

The committee is to be commended for their efforts to compile the available information on alternative agricultural production systems. Most of the concepts which were presented are being successfully used by some farmers. The report should not be considered a research document, but rather a compilation of options which should be thoroughly evaluated in research as possibilities for alternative agricultural production systems.

Comments on *Alternative Agriculture*

Dean R. Zimmerman
Professor of Animal Nutrition
Iowa State University

SUMMARY

The committee has developed a thought-provoking report on alternative agriculture systems. My critique relates specifically to management of animal wastes and strategies to prevent animal disease. Although the committee

report emphasizes and recommends low-input livestock systems, these systems are not always compatible with the best "alternative practices" to utilize plant nutrients from animal wastes and to prevent water pollution. Also, many disease management strategies that reduce the requirement for antimicrobial use are not compatible with low-input livestock systems. Therefore, "alternative agriculture" should not be limited to "low-input" practices.

REVIEW*

The committee on the Role of Alternative Farming Methods should be complimented on developing the report. The report has and will stimulate thinking, discourse and, hopefully, financial and manpower resources to conduct scientific research to evaluate alternative methods. Also, it points out the important interactions between governmental farm policies and implementation of alternative practices.

My critique of the report relates specifically to the involvement of livestock in alternative practices. The report emphasizes the importance of management of animal wastes, management strategies to prevent disease and the importance of genetic improvement for disease resistance. These are important areas. Therein lie many opportunities for research and for application, including goals to protect surface water and ground water supplies from contamination, to efficiently preserve and apply plant nutrients from animal wastes, to improve animal production efficiency, and to decrease the need for antimicrobials in disease prevention and treatment.

Animal Waste Preservation and Application

It is accepted that nitrogen and phosphorus from animal wastes can and sometimes do pollute on-site and off-site water sources. Prevention of water pollution by animal wastes will require improved methods of storage, preservation, distribution, and utilization of the plant nutrients in animal wastes. It may also require limitations on animal numbers at specific sites. Some of these goals are compatible with low-input alternate livestock practices, but others may require increased production costs and may be more compatible with confinement systems, than with extensive livestock production systems. For example, waste runoff is a hazard from open feedlots and pasture or dirt lots, whereas it is not a potential problem with livestock confined to buildings. It is my opinion that reduction of input costs in livestock production is a worthy goal, but it should not be a requirement of "alternative practices" as is implied in the Executive Summary of the report (page 3).

Disease Prevention

As indicated earlier, management strategies have a big impact on the "disease level" in livestock enterprises. Various strategies are being successfully utilized by producers. There is, however, a great need for additional research and application. Examples of disease management tools that are successfully used by swine producers include: "all-in-all-out" housing; closed herds; limited-access facilities; rodent, bird, and wild animal control; cleaning, disinfecting, and floor sealing; exposure of replacement gilts to aged sows; confinement to concrete floors; temperature and humidity control; and use of antimicrobials. Some of these tools can be utilized in "less-intensive" livestock production systems recommended in the report. However, others require the use of confinement facilities.

The committee (pages 168 to 177) takes issue with the indiscriminant use of antimicrobials (antibiotics) in livestock production. It is indicated that some livestock producers rely toe heavily on antibiotics, when a better strategy would be to apply other management tools to limit the "disease level" and thereby minimize the need for antibiotic use. The potential risks, both real and perceived, associated with the use of antimicrobials in animal agriculture warrant the goals of proper and minimum use of these compounds.

The committee reached a conclusion that certain alternate management systems and techniques can greatly reduce the reliance on subtherapeutic feeding of antibiotics. They suggested that increased use of pasture and outdoor rearing facilities will decrease the need for antimicrobials. The committee's conclusion is based on a report by Kliebenstein et al. (1981) and the case studies of the BreDahl, Kutztown, Thompson, and Coleman farms. In the Kliebenstein et al. (1981) study, production costs on eight farms utilizing pasture facilities were compared with costs on 48 farms utilizing confinement facilities. In the comparison, veterinary and medicine expenses averaged $0.35/hundred pounds of market weight (cwt) for pasture systems and $0.74/cwt for confinement systems. The senior author of this report (Kliebenstein, personal communication) does not believe that the data set was large enough to justify the conclusion that there is less disease and need for antimicrobials in pasture than in confinement systems of pig production. Regarding the other references, only the Thompson farm has a sizable swine enterprise (90 sows) and no pigs are raised on the Coleman farm. Subtherapeutic antibiotics are not used on the Thompson farm, but records are not furnished and tests are not reported that would substantiate the above conclusion that use of subtherapeutic antibiotics would not be an economic management tool on this farm.

Circumstantial evidence is available indicating that the use of subtherapeutic antibiotics are of economic value even in "low disease level" environments. The reports by Hays (1979) and Zimmerman (1986) indicate that subtherapeutic levels of antimicrobials improve production efficiency of pigs, particularly early in life. Most of the research data included in these reviews were from studies conducted at governmental experiment stations, where disease levels and other environmental stressors would be expected to be lower than would be the case in "on-farm" production facilities.

In the Thompson case study, it is stated that antibiotics create a "vacuum" in the gut of an animal, a "vacuum" into which resistant pathogens may move with relatively few constraints. No scientific evidence is given to support this statement. Additionally, the committee indicated that probiotics are used as feed additives in place of antibiotics to prevent diarrhea. Again, no references are given to substantiate the effectiveness of the probiotics. Most of the controlled feeding trials at experiment stations to evaluate probiotics indicate little or no growth, feed efficiency, or diarrhea-control responses.

Summary

The committee has developed a thought-provoking report on alternate agriculture systems. As it regards livestock production, the committee's emphasis on management of animal wastes and management of livestock diseases are certainly appropriate. However, the idea that "less-intensive" livestock systems (e.g., pasture-rearing of pigs) are the preferred methods to manage animal wastes and livestock diseases is questionable and is not supported by the scientific literature. In most instances, successful methods of managing animal wastes and livestock diseases are not "low input."

Literature Cited

Hays, V. W. 1979. Benefits: Antibacterials. *In* Drugs in Livestock Feed, Vol. I. Technical Report. Pp 29-36. Office of Technology Assessment, Congress of the United States, Washington, D.C.

Kliebenstein, J. B., C. L. Kirtley, and M. L. Killingsworth. 1981. A comparison of swine production costs for pasture, individual and confinement farrow-to-finish production facilities. Special Report 273. Agriculture Experiment Station, University of Missouri, Columbia.

Zimmerman, D. R. 1986. Role of subtherapeutic levels of antimicrobials in pig production. *J. Anim. Sci.* 62:6.

6

Crop and Soil Sciences

Alternative Agriculture
A Timely, but Flawed Report

Samuel R. Aldrich
Professor Emeritus, Soil Fertility Extension
University of Illinois at Urbana-Champaign

SUMMARY

This is a timely, but seriously flawed report, especially the recommendation for research, its centerpiece. Modern research methodology (based upon carefully controlled treatments adequately replicated) has been painstakenly developed over more than 50 years since the science of statistical design emerged. This would be replaced with a "whole-farm approach" from which cause/effect relationships could not be identified, hence results could not be correctly interpreted, nor could practices be properly selected for use on other farms. For example, when the whole farm is a financial success, the effects of individual practices are masked and those with negative effects are erroneously credited as being positive.

REVIEW

Because of the success of past research and widespread adoption of the results by farmers, we can now afford the luxury of reexamining our production strategies as in the National Research Council report on Alternative Agriculture. The report is timely and addresses important issues. Unfortunately, it is flawed in several respects, most importantly in the research it proposes. The research methodology, so carefully crafted by agricultural scientists, mainly during the past sixty years, would be discarded in favor of amassing detailed records of farm practices from which no amount of data massaging could produce cause/effect relationships which are the very essence of modern research. In the language of researchers, the effects are confounded.

Understandably, whole-farm success stories have great media appeal. Furthermore, the concept of measuring the effect on crop yields of putting together the best package of practices on farms is deceptively attractive to many persons who are not fully knowledgeable in research techniques in agriculture.

The connotation of "alternative agriculture" is that things will be done differently than in "conventional agriculture." In fact, the goals set forth in the NRC report differ little from those that have been widely endorsed and promoted by agricultural extension workers. Many conventional farmers, of course, can improve their performance, but the NRC report unfairly misrepresents and discredits farmers' goals and those of agricultural researchers and extension personnel.

Proponents of the whole-farm approach to research evidently are unaware that, since the effects of individual practices cannot be identified, some that have a negative effect may be hidden and mistakenly assumed to be positive if the overall system is economically successful.

Researchers design experiments so that statistical treatment of the results provides a basis for assessing confidence in the findings. Whole farms do not lend themselves to such statistical treatment.

The report properly notes that some of the economically successful farms benefited from higher-than-market prices in special markets for "organic food." But, a widespread switch to "alternative agriculture" would eliminate that advantage. The same can be said for farms that obtained poultry or large animal manure from outside sources. That not only gave them an economic advantage, but also robbed soil fertility on "Peter's farm" to benefit "Paul's farm."

A thesis in this report—that agricultural research has been too fragmented and insufficiently tied together for farmers—underestimates the capacity of modern farmers to put together systems well adapted to their soil, climate, markets, financial resources, and personal characteristics.

I am dismayed at the statement (page 19) that "alternative means for controlling the supply and price of foods and vegetables should be developed." Government involvement to the extent inferred by that statement has increasingly been repudiated wherever practiced in the world.

An increase in crop rotations that include leguminous crops is a major recommendation in the report. It states that diversity will stabilize income, reduce erosion, and provide nitrogen. It is not economically sound to introduce diversity in order to minimize annual fluctuations in income wherever present specialized systems produce the highest long term income. Farmers are sufficiently intelligent and informed to have diversified where it is advantageous.

Erosion reduction achieved on a field (or on a farm with similar topography overall) through a rotation that includes forages is an illusion when viewed from a broader standpoint. For example, erosion is minimized on a hill/valley farm when row crops are concentrated on the flat land and close-growing crops are planted on sloping land. At the national level, erosion and water pollution are minimized through specialization in corn and soybeans in the Corn Belt where the land is less erosive than in many other areas.

The NRC report states that "Substituting manure or legume forages for chemical fertilizers can significantly reduce fertilizer costs." The authors appear to be unaware that manure returns only a portion of the nutrients that were removed in the previous crop. A system based solely upon the return of manure gradually depletes the soil of all nutrients except nitrogen, hence is not sustainable.

Widespread replacement of conventional agriculture with the committee's version of alternative agriculture (greater diversification, less fertilizer, pesticides and antibiotics) would reduce overall production by at least 15%. It would be further reduced through loss of shelf life and spoilage of perishables.

If protected against imports, aggregate farm income under alternative agriculture would likely not suffer and might increase. A special burden would, however, fall on low income persons in the form of higher food prices. The system would also have a detrimental impact on the U.S. trade balance.

In order to efficiently utilize leguminous crops in more diversified systems, the report acknowledges that forage-consuming livestock are essential. I find no discussion of the implications of that. Is there a market? Is increased consumption of livestock products advisable? What is the potential for water pollution from animal manure versus fertilizer?

This is not an even-handed assessment of two systems. It is overly critical of conventional agriculture and unrealistically optimistic about alternative agriculture. It does not adequately credit conventional agriculture with changes made in the past, now in progress, or on the horizon. For example, integrated pest management (IPM) is identified as an important component of alternative agriculture, but it has been studied intensively, promoted extensively, and widely adopted for more than ten years.

There is a growing antiscience movement. Intentionally or not, the way this report treats traditional agricultural research and extension strengthens the hands of those critics who have few qualifications to properly assess the technologies involved. The NRC committee would have been well advised to make a clear statement endorsing much past and current agricultural research.

The *Alternative Agriculture* Report

Charles A. Black
Emeritus Professor, Department of Agronomy
Iowa State University

SUMMARY

In this review, comments are made on the philosophy of alternative versus conventional agriculture, empirical support for alternative practices, some

consequences of eliminating incentives for high production, pest control alternatives, pesticide regulation, production costs, crop rotations, legumes, and the Green Revolution.

REVIEW

Alternative Versus Conventional Agriculture

The *Alternative Agriculture* report (Pesek et al., 1989) fosters the impression that alternative agriculture and conventional agriculture are two different things. But the statements of practices and goals of alternative agriculture on pages 17 and 27 of the report probably would be accepted by most agricultural research and extension specialists as about the way they look at conventional agriculture, with the important proviso that the alternative practices be as profitable or more profitable than practices in current use.

The *Alternative Agriculture* report probably will give some casual readers the impression that alternative practices are ready and waiting, having been proved just as profitable as conventional practices and needing only a change of attitude for adoption. For example, one reads on the back cover of the report that "Alternative farming methods are practical and economical ways to maintain yields, conserve soil, maintain water quality, and lower operating costs through improved farm management and reduced use of fertilizers and pesticides." On page 8, "Successful alternative farmers often produce high per acre yields with significant reductions in costs per unit of crop harvested." And on page 6, "Wider adoption of proven alternative systems would result in even greater economic benefits to farmers and environmental gains for the nation."

The impression created by these quotations is deceptive. It is not supported by the case studies (see the following section in these comments). Moreover, one reads on page 6 that "the scientific knowledge, technology, and management skills necessary for widespread adoption of alternative agriculture are not widely available or well defined." This statement appears closer to the mark than the enthusiastic descriptions of the virtues of alternative agriculture in the preceding paragraph, as evidenced by the fact that the report has very little to say about new technologies and practices that should be adopted as alternative agriculture. Rather, it promotes the use of certain existing technologies, some of which are old. This is to be expected in view of the way the system works.

As new technology and knowledge become available and are hammered out on the anvil of practice, they foster change. Agricultural research and development are done in both the public and private sectors. The Extension Service delivers information to the farm community. Industry promotes its products. The media publicize new information. Farmers do their own testing and adaptation of new practices, and they pass information along to their colleagues by word of mouth. In view of this system, the existence of any considerable body of profitable but unadopted alternative practices that are not in the process of testing and adoption is unlikely.

Changes in agricultural technology may be adopted only very slowly if incentives are inadequate, as evidenced by soil conservation practices in general. On the other hand, if incentives are adequate, some changes in agricultural technology are widely adopted in the span of a few years, as evidenced by hybrid corn, integrated pest management, and conservation tillage.

For the most part, agriculture is a profit-driven industry. As a consequence, even more rapid changes can be encouraged by government programs with strong financial incentives. Farmers respond to these programs in part by altering their production technologies.

Empirical Support for Alternative Practices

The *Alternative Agriculture* report offers 11 case studies as empirical support for the practices it advocates. Reduced use of agricultural chemicals is a unifying theme. Reduced use of agricultural chemicals except through integrated pest management (largely for insect control), however, seems to have its financial problems. Those farmers are probably rare who would not like to reduce their expenditures for agricultural chemicals if they could do so without loss of profit and convenience.

In the extreme situation represented by Case Study No. 11, one learns on page 399 that "The experimental (nonchemical) rice yields 44 hundredweight versus the Lundbergs' 74 hundredweight/acre conventional average, or the 110 hundredweight/acre on the most productive farms in the county. Experimental nonchemical rice is generally less profitable than conventionally produced rice despite premium price, due to insufficient nitrogen and lower yield. Premium prices for yields in organic rice would dissipate if production increased significantly." The premium received for the rice produced without fertilizers or pesticides is said to be about 50%. On page 416, "The Lundbergs reported that they were subsidizing their experimental rice production by approximately $50,000 per year in 1982."

In the description of the "Coleman Natural Beef" enterprise (Case Study No. 10), one reads on page 389 that "The 25 percent premium above regular carcass prices is key to the profitability of the operation." As regards profitability, "the owners report that the Coleman ranch is currently earning a return on labor and management that is less than the wages they pay their hired personnel. The rate of return on their investment thus is extremely low—if not actually negative—at present" (page 397). "Jim Coleman's wife works as a school nurse in Saguache to help cover family living expenses" (page 390).

The Coleman Natural Beef enterprise involves 2,500 cow-calf units on 21,500 acres of owned land plus 13,000 acres of leased land and 250,000 acres of Forest Service and Bureau of Land Management land. The average population density is thus one cow-calf unit per 114 acres of land. This low density no doubt contributes to animal health by helping to reduce the transmission of diseases, but some animals still get sick. Sick animals are segregated from the others, treated as needed, and removed from the "natural beef" program. Even the cattle in the natural beef program are injected with medicaments to control scabies, lice, brucellosis, blackleg, and malignant edema.

Four additional farms included in the case studies received some premium for part of their produce. In three of the four, the premium did not appear decisive in the financial viability of the operations. One of these, the Pavich farm, used purchased composted steer manure, fish waste, and kelp in place of commercial fertilizers and used sulfur in place of synthetic organic fungicides to control fungal diseases on the grapes produced as the farm's principal product. The estimated cost of pest-control materials was given as $220 per acre compared with $141.81 for the "University of California enterprise budget" for conventional operations (page 370).

Extensive economic analyses have been made of Case Study No. 4 in Pennsylvania. According to the summary of the enterprise on page 288, "Expenditures for fertilizers and agricultural chemicals per acre are substantially below county averages. Investment in machinery is very low because of the age of the equipment; repair costs are high (mostly for parts). Economic analysis indicates the Kutztown Farm is somewhat less profitable than a comparable conventional farm." Part of the land is farmed "on a special lease requiring that agricultural chemicals not be used" (page 294). The farmer uses crop rotations to suppress weeds and insects on both the leased and nonleased land, but he reports that weed problems persist and that "If we have wet weather during critical cultivating time, weeds can take over." Seemingly for these reasons, he uses herbicides on the nonleased land (page 300).

Case Study No. 3 is on a farm in Virginia. On pages 284 and 285, one reads that "Cost and returns data for the Sabot Hill Farm are not available for presentation in this case study. Yet some generalizations can be made. Cash operating costs are low in comparison with those of farms dependent on purchased feed, and the Fishers have reduced their herbicide costs by about $20,000 through cultural practices."

The farm has a problem with Johnsongrass, which is a persistent weed. In preference to controlling the weed with herbicides, the Fishers accept it as a component of the hay they produce. They also "use a corn variety that . . . is resistant to viruses carried by the Johnsongrass but produces yields of from 10 to 15 percent less than other cultivars that do not have this resistance" (page 280).

Case Study No. 2 is on a farm in Iowa. On page 267, one reads that "Costs are reduced by the use of on-farm resources (feeds, nitrogen fixation, operator labor) rather than relying on purchased inputs. The farm's cash flow obviates the need for borrowed capital. Net returns from the farm are adequate to support the family during most years. . . . The farmer's wife works off-farm as a teacher." On page 274, "The family's financial goal, although not always achieved, has been to make a living from the farm and to save Linda BreDahl's teaching salary."

Case Study No. 5 is on a second farm in Iowa. On page 309, one reads that "Municipal sludge is provided free of charge; only a limited number of farms can receive this free resource. Costs are kept low by the use of on-farm resources, such as N_2 fixation and labor. Corn and soybean production costs are lower than for conventional farms. Farm cash flow is adequate to meet operating costs without borrowing, to maintain and enhance the capital stock of machinery and facilities, and to support the farm family." This operation appears to be more successful than some of the others. The farmer is well educated, a leader, and an innovator. According to a personal communication from Dr. William D. Shrader, Professor of Soil Management (retired) at Iowa State University, the farmer has some of the best land in the county in which he lives. The relatively high inherent productivity of the land thus may contribute to the farmer's success.

Case Study No. 7 is on four vegetable farms in southern Florida. These farms are heavy users of agricultural chemicals, but expert advice from professional integrated pest management personnel has reduced their use of some chemicals, especially insecticides. An important aspect of the integrated pest management routine is the use of plastic mulches, which eliminate the need for herbicides. The plastic mulch system also involves fumigation to suppress nematodes, disease organisms, and insects in the soil (page 341). One grower (page 348) reported use of 180 pounds of methyl bromide per acre as a fumigant, which suggests that the integrated pest management system has increased the total use of pesticides. On page 337, one reads that "No yield impacts were reported. All four farms appear to be financially sound."

In summary, it appears that the main features differentiating the case studies from conventional agriculture are (1) the substitution of labor and land for pesticides and animal health products and the substitution of off-farm sources of organic soil amendments for commercial fertilizers and (2) the premium prices received by several operators for the "organic" or "natural" products they sold. Integrated pest management, which the writers of the report seem to regard as a part of alternative agriculture, has been adopted to such an extent that it probably should be classed as a part of conventional agriculture. This reviewer concludes that the report's glowing references to financial viability of alternative agriculture are hardly justified by the case studies cited.

Some Consequences of Eliminating Incentives for High Production

The report targets government program incentives as the prime cause of the problem it sees in input use. Eliminating current government incentives for economically unrealistic high production would reduce the income of farmers enrolled in government programs, but would tend to benefit farmers using agricultural chemicals sparingly or not at all by decreasing the production of program crops, which would increase the market price. Eliminating the incentives probably would also encourage greater production of "organic" foods, which would quickly saturate the small market and virtually eliminate premium prices.

Two stages in potential economic adjustments in agricultural production related to the use of agricultural chemicals and other production-enhancing off-farm inputs may be perceived. The first is eliminating government program incentives that create an artificial market and distort production practices to satisfy this market, while permitting the adjustment of agricultural practice in the direction of maximizing the profits of individual farmers on the basis of the economics of the various systems that develop. The second is eliminating the program incentives and going further by adopting devices that would reduce the availability or increase the cost of certain inputs. The first stage would increase economic production efficiency, but the second stage would decrease it.

Although the favorable aspects of reducing the use of agricultural inputs are well emphasized in the *Alternative Agriculture* report, a special point on the other side that merits mention is efficiency of land use. As put by Borlaug and Dowswell (1988), "if U.S. farmers used the agricultural technology of the 1930s and 1940s to produce the harvest of 1985, they would have to convert 75% of the permanent pasturelands in the United

States or 60% of the American forests and woodland areas to cropland. Even this may be an underestimation, since the pasture and forestlands are potentially less productive than the land now planted to crops. This would greatly accelerate soil erosion and destroy wildlife habitats and recreational areas." A more detailed overview of effects could be derived from a careful economic study, such as the one published by Olson et al. (1982) comparing conventional farming and "organic" farming.

Pest Control Alternatives

The report notes on page 175 that "most of agriculture relies on synthetic chemical pesticides, even though in many cases effective alternatives are now available." Although the situation is stated in a way that may appear derogatory to conventional agriculture, the facts of life with conventional agriculture are the same as they would be if one were to change the term and call it alternative agriculture. That is, if new alternative products are effective and appear capable of yielding a substantial profit, they are developed by commercial concerns. (Page 183 gives pheromones as an example.) If farmers adopt the products, the commercial firms prosper. If only a change in practice is required, only farmers need to be satisfied that an alternative procedure is superior in terms of economics, convenience, or both.

Promoting substitutes for pesticides, the report states on pages 179 and 180 that "Natural biological controls, such as antagonists, predators, and self-defense mechanisms, suppress most pests. Biological control of pests by natural enemies (parasites, predators, and insect pathogens) is partially or entirely effective on most potential pests. Additionally, this sort of control is long-lasting if it is not disrupted by farming practices such as insecticide use, certain crop rotations, or unusual climatic conditions."

On page 224, however, one learns that "biological control research is often location and management system specific. Effective biological control systems must be carefully researched and tailored in light of seasonal weather patterns, crop conditions, and pest population trends and interactions." And, on page 185: "The introduction or application of biological control agents has not been very successful with plant pathogens because of the great complexity in microbial communities. Although many of the management practices that indirectly control diseases strike a balance between beneficial and deleterious microorganisms, there is insufficient knowledge to effectively develop and use biological control agents commercially (Schroth and Hancock, 1985)."

Pesticide Regulation

Reducing the use of fertilizers and pesticides, especially the latter, seems to be a prime objective of the writers of the *Alternative Agriculture* report. To aid in accomplishing the objective, recommendations are made (page 19) for regulatory impediments to be placed in the way of pesticide approval. And if this does not prove to be enough of an obstacle, the report recommends on page 23 that "Regulatory policy may play a role, particularly in raising the cost of conventional practices to reflect more closely their full social and environmental costs." As an example of the regulatory policy approach, the report states on page 219 that "The EPA and the USDA should jointly develop and formally adopt a set of improved procedures for assessing the economic value of pesticides in the context of risk-benefit decision making already required by federal law. The benefits of a pesticide should be characterized as the difference between the total value of harvested commodities and the total value of the same crop using the next best alternative, which may involve an alternative cropping system that requires little or no pesticide use. Consideration of the costs of health and environmental risks of pesticides should be included in these analyses."

The recommended procedure presumably applies to the risk-benefit reviews of individual registered pesticides made by the Environmental Protection Agency. The Agency uses the results of the reviews for deciding whether the pesticides should continue to be used without restrictions, whether use restrictions should be applied, or whether the pesticides should be banned.

Two significant problems with the recommended procedure come to mind. First, looking at the risks and benefits of a given pesticide in the manner described does not take into account the propensity of pests to develop resistance to pesticides and other control measures, including resistant crop varieties. This weakness in pest control practices in general makes it important to have available more than one control mechanism, so that substitutes may be brought forward as needed if some of the practices should fail.

Second, the proposed procedure does not do justice to the importance of a given pesticide for minor users. As a specific example, more than 80% of the tomatoes grown in the United States are for processing, and 84% of the processing tomatoes are grown in California (GRC Economics, 1989). Hence, the economics of producing processing tomatoes is dominated by California. California growers use fungicides, but the relative humidity is low enough that the disease problem is far less serious in California than it is in humid regions. The tomato disease commonly known as leaf spot that is devastating in humid regions without a suitable fungicide is not a problem in dry areas. As a consequence of the proposed procedure, however, tomato growers in humid regions could be denied the use of a pesticide that is essential to their livelihood.

On page 12, the report notes that "Federal grading standards, or standards adopted under federal marketing orders often discourage alternative pest control practices for fruits and vegetables by imposing cosmetic and insect-part criteria that have little if any relation to nutritional quality." What the writers of the report mean by this is that "in many cases" the integrated pest management methods they advocate "are less effective than routine spraying for controlling cosmetic damage" (pages 12 and 13). The writers advocate changing the rules so there will be no discrimination in the grading stage against less-than-clean products. Thus, the present system is regarded as inappropriate because it results in economic discrimination against integrated pest management. The writers of the report would replace the present system with one that results in economic discrimination against pesticides.

Depending upon the product, perhaps most cosmetic blemishes are of no consequence in terms of nutritional quality or safety as long as they remain cosmetic. One must appreciate, however, that although the damage by pests against which pesticides and alternative pest control practices are directed is initially cosmetic because it starts at the surface, some of it works inward. The surface blemishes that the writers of the report would have one tolerate may facilitate or mark the entry of organisms that hasten the deterioration of the product or produce toxins.

One wonders if the writers of the quotation from page 12 of the report have ever eaten an apple under the circumstances in which they felt constrained to check each round brown spot and each place the skin was broken to be sure these cosmetic blemishes did not cover worm holes, and to inspect the apple repeatedly during consumption to see if the last bite had exposed any worms, parts of worms, or worm holes. Conversion of some of the apple flesh to worm protein may have only a small influence on the nutritional quality, but for most people this probably is not the issue.

Production Costs

The *Alternative Agriculture* report includes a chapter on "Economic Evaluation of Alternative Farming Systems," but the data for crop production have to do with production costs. As a concluding truism, the report states on page 205 "that the most profitable alternative and conventional farms are often those that successfully cut back on fertilizer, pesticide, and machinery expenses while sustaining high levels of crop production." The obvious question of course is what kind of management magic can be called up to sustain high levels of production when the proven means of such production are withdrawn.

One of the data sets included as evidence is for soybean production in southwestern Minnesota in 1986 (Table 4-5, page 206). Variable costs were higher by $21.14 per acre, and fertilizer and pesticide costs were higher by $5.33 per acre on high-cost, low-income farms than on low-cost, high-income farms. The inference one presumably is supposed to make from these and other similar data is that cuts in expenditures for fertilizers and pesticides would improve profitability.

In a paper commenting on the *Alternative Agriculture* report, Gianessi (1989) pointed out that the report does not cite a study in southeastern Minnesota in 1986 in which total variable costs of soybean production were $26.46 higher per acre on low-return farms, but fertilizer and pesticide costs were $3.28 higher on high-return farms. In both studies, the costs of fertilizers and pesticides were only a minor part of variable production costs, but neither account reported the critical information on the profitability of these inputs. Such information is not available from the farm accounting records used to provide the data cited.

Crop Rotations

The report misrepresents some of the information on crop rotations and does not do justice to the critical economic bottom line. Regarding a crop rotation experiment in Nebraska, the report states on page 233 that "The continuous cropping systems were found to require higher pesticide expenditures and be subject to greater year-to-year variations in yields and profits per acre compared with the various rotations (Helmers et al., 1986)."

Similar comments about year-to-year variations citing the same paper are found on pages 78 and 199.

The paper by Helmers et al. (1986) does not contain information supporting the statement on pesticide expenditures. Moreover, the paper does not support the statements about year-to-year variations. Although returns from continuous corn were highly variable, the net returns from continuous soybeans had the lowest variability of all the cropping systems tested, including the 4-year rotations.

The data from the Nebraska experiment show that if Marten's (1989) figure of $125 per acre for land costs is included, the only cropping systems that were profitable were continuous soybeans, a 2-year rotation of soybeans with corn or grain sorghum, and a system in which soybeans were grown continuously on half of the land and grain sorghum was grown continuously on the other half. Continuous corn was a money loser, as were the 4-year rotations. Subsidies associated with government program participation were not included in the analysis.

An economic analysis of an Iowa experiment by Duffy and Chase (1989) showed that the only cropping system that would have been profitable without the government program, after subtracting $105 per acre as the cost of the land (Duffy, 1988), was the corn-soybean rotation. The money-losing cropping systems included continuous corn, corn-corn-corn-oats, corn-soybeans-corn-oats, corn-corn-oats-meadow, and corn-oats-meadow-meadow. Meadow is a legume-grass mixture cut for hay.

Legumes

The *Alternative Agriculture* report repeatedly extolls the virtues of legumes as sources of nitrogen for nonleguminous crops in crop rotations, and the desirability of using them as substitutes for fertilizer nitrogen. The report suggests also the desirability of genetically engineered "legumes and bacteria that more effectively fix nitrogen" (pages 16 and 17).

Valuable as they are, legumes do not supply as much nitrogen as is usually desired. Legumes can and are being improved in nitrogen-fixing capability. Some day, genetic engineering may make possible the fixation of enough atmospheric nitrogen by nonleguminous crops to meet their needs. This would be a tremendous scientific and humanitarian achievement. It would eliminate the need for nitrogen fertilizers and would eliminate the need for legumes as sources of nitrogen for other crops in the rotation.

But the biological fixation of enough nitrogen to meet crop needs would be merely a sidewise shift from one source of nitrogen to another. In the soil, the end product of nitrogen fixed by legumes and the nitrogen that some day might be fixed by nonlegumes is nitrate, just like that of the nitrogen added in fertilizers.

The point is that the substitute for fertilizer nitrogen advocated by the report is the same kind of nitrogen as that contained in fertilizers, and it produces the same kind of nitrate, which may enter groundwater and appear in drinking water. At present, the substitute produces less nitrate than fertilizer nitrogen, mostly because the legumes do not supply as much nitrogen. The more nitrogen is supplied by biological fixation, the more nearly the loss of nitrate from the soil in the drainage water will approach that associated with the levels of nitrogen fertilizer required to produce high yields.

The Green Revolution

On page 25, the *Alternative Agriculture* report states that "Many of today's common practices were the alternative practices of the postwar era. One example is monocultural production, which synthetic chemical fertilizers and pesticides made possible. The widespread adoption of these alternatives, referred to internationally as the 'Green Revolution,' led to dramatic increases in per acre yield and overall agricultural production in the United States and many other countries."

Description of the "Green Revolution" as monocultural production made possible by synthetic chemical fertilizers and pesticides implies a misunderstanding of the nature of the phenomenon. Making appropriate applications of fertilizers and pesticides to the native varieties of wheat and rice in Third World countries would have made some improvement in crop yields, but nothing like what was accomplished in the Green Revolution. The basic and essential ingredient in the Green Revolution was short, stiff-strawed, widely adapted varieties of wheat and later rice. These new varieties produced higher yields than the tall native varieties in Third World countries. Under favorable conditions of water supply and soil fertility, the new varieties yielded up to four times as much as their predecessors. "Monocultural production" was not an essential ingredient. Wheat and rice were often grown continuously long before the Green Revolution, and the practice persists.

Borlaug and Dowswell's (1988) views on the Green Revolution are worth reading. The last paragraph of their article includes perceptive comments about the negative impacts of the alternative agriculture movement on Third World countries.

Literature Cited

Borlaug, N. E., and C. R. Dowswell. 1988. World revolution in agriculture. Pp. 5-14. *In* 1988 Britannica Book of the Year. Encyclopedia Britannica, Inc., Chicago.

Duffy, M. 1988. Estimated costs of crop production in Iowa—1989. FM-1712 Revised, December 1988. Iowa State University Extension, Ames.

Duffy, M. D., and C. A. Chase. 1989. Impacts of the 1985 Food Security Act on crop rotations and fertilizer use. Unpublished manuscript, Department of Economics, Iowa State University, Ames.

Gianessi, L. P. 1989. Alternative agriculture: Insights into the benefits of agrichemicals. Paper presented at the 1989 fall conference of the National Agricultural Chemicals Association, Arlington, Virginia, October 19, 1989. The author is at Resources for the Future, Washington, D.C.

GRC Economics. 1989. The value of fungicides to the availability of a healthy and affordable food supply. GRC Economics, Washington, D.C.

Helmers, G. A., M. R. Langemeier, and J. Atwood. 1986. An economic analysis of alternative cropping systems for east-central Nebraska. *Amer. J. Altern. Agric.* 1:153-158.

Marten, J. 1989. Will low-input rotations sustain your income? *Farm J.*, December 1989, p. 6.

Olson, K. D., J. Langley, and E. O. Heady. 1982. Widespread adoption of organic farming practices: Estimated impacts on U.S. agriculture. *J. Soil*

and Water Conserv. 37:41-45.
Pesek, J., S. Brown, K. L. Clancy, et al. 1989. *Alternative Agriculture.* National Academy Press, Washington, D.C.

Alternative Agriculture and Related Myths

Donald N. Duvick
Senior Vice President/Research (retired)
Pioneer Hi-Bred International, Inc.

SUMMARY

The report *Alternative Agriculture* presents the case for adoption of alternative farming practices intended to improve the ecological and economic well-being of U.S. agriculture. It does so in a scholarly, data-based manner, pointing out lack as well as presence of supporting data, and noting possible disadvantages as well as expected advantages in adoption of specific alternative agriculture practices. Recommendations tend to take the middle ground between *status quo* and strongly antichemical views, but with a bias always in favor of a biological approach and against a simplifying chemical and/or engineering approach.

REVIEW

Myths sustain the human race. They contain impossibilities and strain our credulity but they also crystallize our perception of the greater good, of ultimate goals, and galvanize us into needed action.

The beliefs subsumed in the term, "alternative agriculture," comprise such a myth. These beliefs collectively point toward the goal of an ecologically benign agriculture producing wholesome food, thus ensuring continuity and safety of food supplies, globally. They are based on the assumptions that today's agriculture (particularly in the first world) is dangerously dependent on unsafe chemicals made from fossil (i.e., nonrenewable) fuels, on engineering rather than biological solutions for crop-growing problems, and on large-scale specialization rather than small-scale diversification to solve economic needs of the farming community.

Further assumptions are that for at least the past thirty years a combination of agribusiness, government, and university forces (sans farmers themselves) has pushed agriculture in the above-noted dangerous directions, that the public at large must be warned of the consequences of continuing in such directions, and that actions must be taken to move agriculture toward production practices that are more benign—ecologically, biologically, and sociologically.

The goals of alternative agriculture are laudable and essential for human survival.

The beliefs and assumptions that have led to these goals are based, for the most part, on logic and example rather than on specifically designed experiments and broadly-based, thoroughly-analyzed data sets.

Because such prescriptive use of logic unsupported by experimentation, and of examples not backed up by broadly-based data sets, is antithetical to the beliefs and practice of the agricultural science establishment, the establishment—much of it—has reacted with shock and anger to pronouncements of the alternative agriculture proponents. (After all, 150 years ago the forefathers of what is now the scientific establishment fought for the principle that science must be based on experimentation and repeatability.)

Representatives of the establishment have pointed to data and experiments which refute or at least disagree with specific assumptions or even with broad aims of alternative agriculture proponents. From these information bases, establishment representatives have gone on to say that the present systems (with some updating) are both desirable for agriculture and desired by agriculturalists.

Noting that to defend the *status quo* in agriculture also automatically defends those responsible for present farming practices, proponents of alternative agriculture reacted to the establishment's refutations with accusations that the establishment was inflexible, unable to alter its fondly-held beliefs (myths?), unable to understand that its science was not broad enough to prescribe for today's world, and perhaps unwilling to allow changes in agricultural practice that would reduce the establishment's power and profits.

Into this on-going battle, the National Research Council's Board on Agriculture has introduced the report, *Alternative Agriculture* (National Academy Press, 1989), written by the Committee on the Role of Alternative Farming Methods in Modern Production Agriculture.

The report goes squarely to the aims of alternative agriculture: "the objective is to sustain and enhance rather than reduce and simplify the biological interactions on which production agriculture depends. . . .", and to the criticisms directed at alternative agriculture: "Experience and research have led to a detailed understanding of some alternative methods. But many others are not well understood. Consequently, it is hard to predict where and how specific alternative practices might be useful."

The report was generally headlined as a strong endorsement of alternative agriculture, a refutation of present day practices.

In the words of one reviewer (Wes Jackson, of The Land Institute), "Those responsible deserve our gratitude for exposing the farmers' chemical addiction and for helping farmers everywhere to have cropping arrangements that make it possible to just say "no" to the chemical cartels that blight our land."

The report indeed does say, in the lead statement of its executive summary conclusions, "Farmers who adopt alternative farming systems often have productive and profitable operations. . . . " (page 8). And another highlighted statement in the executive summary says, "Research at private and public institutions should give higher priority to development and use of biological and genetic resources to reduce the use of chemicals, particularly those that threaten human health and the environment" (page 16).

But the report also says that the case is far from proven that alternative agriculture really can work: "The committee's case studies and review of available data illustrate that alternative farming is often profitable, but the sample is too small and unrepresentative to justify conclusions about the precise economic effects of widespread adoption of specific practices or systems" (page 22).

Further, the report often defends present agricultural practices, comparing them favorably with alternative agriculture's goals. It also notes potential problems with certain recommended alternative farming practices.

"Crop management practices, rotations, genetic improvements through classical plant breeding, and synthetic organic chemicals are widely used to control pests in modern commercial agriculture. Steady progress has been made in these areas, and much of what has been accomplished is relevant to alternative agriculture" (page 175).

"Classical plant breeding to develop new varieties is the most successful biological method of pest control. Genetic engineering promises to accelerate breeding for pest resistance" (pages 220 to 221).

"Management also affects the amount of legume-fixed nitrogen that drains to groundwater. . . . Unpublished experiments in Michigan (B. Ellis) found more than twice the concentration of nitrates below crop root systems when alfalfa was plowed down than under irrigated or nonirrigated corn. Few measurements have been made of the contribution of legumes to groundwater contamination or, if necessary, how to minimize it" (page 147).

"Naturally occurring phytotoxic allelopathic chemicals, however, may not always be safer than some of the more undesirable synthetic herbicides. . . . The development of herbicide-resistant crops may offer opportunities to substitute safer herbicides for more dangerous herbicides" (page 188).

But, as with the Bible, one can select citations that collectively seem to oppose the main thesis of the work. There is no doubt that in the end the report on alternative agriculture comes down squarely in favor of efforts to promote greater use of alternative farming practices, whenever and wherever possible. It is not primarily a defense for present-day farming practices, it recommends they be changed in many ways.

But it does so without polemics. It instead uses conventional scientific arguments, waged by establishment scientists. Although this is not a stated aim, the report makes the subject of alternative agriculture respectable, by treating it in a respectable way. The report continues (and perhaps officially certifies) the trend established by the research- oriented *American Journal of Alternative Agriculture*.

The report is not inflexible, nor does it claim universal superiority for any one set of alternative agriculture practices. It points out that "Alternative agriculture is not a single system of farming practices. It includes a spectrum of farming systems. . . . " (page 4), and goes on to include organic farming, prudent use of pesticides in integrated pest management systems, crop rotations, plant breeding to improve pest resistance, and low-intensity animal production systems (and several other practices) as encompassed in alternative agriculture.

It takes an evolutionary rather than a revolutionary point of view, saying that as various alternative methods are tried—objectively and carefully—a winnowing process will select those that work and discard those that do not work.

The report defends its case honestly and with candor, citing data and experimental evidence when it can and clearly noting the (frequent) lack of relevant data and experiments when none are on hand to support alternative agriculture proposals, practices or opinions.

In fact, one of the enduring values of the report in years to come will be as a compendium of facts and citations for virtually all that is known of the scientific and experiential foundation for the tenets of alternative agriculture; and, as well, as a compendium of lacunae, of areas where data, experiments and analysis are lacking and are badly needed, to test the utility of alternative agriculture practices and of the thesis as a whole.

The report is not without error. It states, twice, that introduction of fertilizer-responsive crop varieties led to heavier use of commercial fertilizers (pages 38 and 40). The fact is, however, that the introduction of low-cost commercial fertilizers (particularly nitrogen fertilizers) led to higher use rates by farmers starting in the 1960s; this in turn forced plant breeders to bring out new kinds of crop varieties that could withstand the stresses brought on by high fertilizer rates.

But I found only a few such errors, at least in those fields where I have specialized knowledge.

The report deals perhaps less than it should with the economic dislocations that would result from large-scale re-introduction of forage legume and small grain crops to the corn-soybean belt. Considering the space devoted to economic analysis in the report, surprisingly little was said of this problem other than that it could happen (e.g., "Rotations may have their disadvantages, however, particularly in the context of current government subsidies and requirements for federal program participation. . . . Rotations that involve diversifying from cash grains to crops such as leguminous hays with less market value involve economic tradeoffs. . . . " [page 141]).

In the end, I found myself troubled by one consideration that was not discussed in the report, even though data in the report seemed, to me, to lead to the subject. The report repeatedly calls for a systems approach to farming, rather than (or perhaps in addition to) a reductionist approach. It says, correctly, I believe, that only with a systems approach can one evaluate the sum of all the interactive changes that the alternative approach can generate.

But, the report stops short at the individual farm, in its consideration of operating systems. It assumes that the farm is the system, the operating economic—and ecological—unit. Nevertheless, it points out that in every one of the nine major farming regions of the United States, more than half of the total income of the farm population now comes from non-farm sources. (See page 59 for comments and data tables.)

This is important information. It tells us that the occupation of farming no longer stands alone as the sole source of income for the farming population, anywhere in the United States of America. Farming is not even the primary source of income for the farm population. In the aggregate, farming is only one part of a larger, more complex system for generation of income to support the farm population.

The consequences of this fact are large, I believe. For example, mixed crop and livestock farming is cited in the report as a favorable practice for stabilizing agricultural income, due to the diversity of interactions with weather and price variables. It seems to me that farm families often may decide (indeed, many apparently have decided) that a stronger and maybe a simpler way to stabilize incomes is through off-farm employment, of one spouse or both. With such a stabilizer, the up-and-down risks of monocropping or other kinds of specialized farming—on individual farms—may seem quite acceptable.

In fact, with an off-farm income stabilizer in place, there may no longer be enough personal time and energy to devote to the extra effort needed for a thorough-going diversified family farming operation, with complex biological replacements to the simpler insurance applications of chemical protectants and commercial fertilizers.

This is the operating system, then, that really needs study and experimentation: a system that encompasses farm families and all the gainful occupations they pursue, off-farm as well as on-farm; a system that considers area-wide groups of farms and their interactions, as *de facto* operating ecological units.

How can such a system be encouraged to develop in ways that will bring about realization of the goal of alternative agriculture—and of everyone: an ecologically and sociologically benign agriculture, which sustains and enhances the biological interactions that are the basis for all agriculture and for the survival of the human race?

Research Needs and Achievements Identified in the NRC Report Entitled *Alternative Agriculture* are on Target

Gordon C. Marten
Associate Director, Beltsville Area
U.S. Department of Agriculture, Agricultural Research Service

SUMMARY

The National Research Council committee is credited for acknowledging that judicious chemical usage must be incorporated into many sustainable alternative systems of agriculture to meet national needs and to allow efficiency and profitability. Delineation by the committee of research achievements and needs to better understand and promote alternative farming practices is generally well done in the report. Both Federal and State agricultural research institutions need additional funds to pursue creative interdisciplinary research that fosters alternative agriculture systems.

REVIEW

The recommendations and conclusions by the National Research Council committee concerning research and science needs and achievements in alternative agriculture are well stated and on target. The authors give due recognition to the concept that any alternative system of agriculture must be profitable and efficient, as well as resource conserving and environmentally acceptable, to be truly sustainable in modern society. The report recognizes that judicious chemical usage must be incorporated into many sustainable systems of agriculture to meet the needs and demands of our largely urban population in the United States and many other developed countries. Thus, the authors wisely include the prudent and safe use of chemical fertilizers, pesticides, and growth regulators as acceptable components of alternative systems needed for us to thrive and survive in today's global marketplace.

Emphasis by the committee on the need for interdisciplinary, problem-solving research teams to better understand alternative farming practices is also well placed. Their delineation of achievements and needs in a wide array of critical areas indicates scholarly review of current literature. These areas include crop rotation dynamics; plant nutrient cycling in diverse soils; nitrogen fixation by legumes and utilization of this nitrogen by subsequent crops; utilization of animal wastes; influence of tillage practices and soil microbes on sustainability; forage crop utilization by ruminants; potential for forage quality improvement by crop and harvest management and plant breeding; integrated pest control strategies for plant and animal production; biological control of diseases, insects, and weeds; and genetic engineering coupled with conventional genetic selection from diverse germplasm and breeding of improved plants and animals. All of these areas interface with current emphases by public agricultural research establishments, including the Agricultural Research Service of the U.S. Department of Agriculture and the State Agricultural Experiment Stations.

Expansion of both formula funding and the proposed competitive grant funding for public scientists in universities and the federal government, as well as private institutions and industry, to include research needed to undergird alternative agriculture systems would be very welcome. Policy makers have felt the need to fund specific commodity research, but there has been a paucity of unified support for funding of key components of sustainable systems such as production of alternative forage crops, nitrogen fixation, and grazing management. Additional funding is needed to mobilize a "Crusade for Creativity" among agricultural scientists who have a knowledge base and commitment to pursue the interdisciplinary research outlined by the NRC committee.

Comments on *Alternative Agriculture*

Fred P. Miller
Professor and Chairman, Department of Agronomy
The Ohio State University

SUMMARY

Any subjective assessment of a subject is fraught with the danger of being interpreted as conclusive evidence that legitimizes advocates of particular philosophies and systems, many of which have not stood the test of time and scientific evaluation protocols. Several of the case studies have since

undergone significant production changes due to economic and production problems, including weed pressure. Furthermore, the report tends to bifurcate the spectrum of agricultural systems into those qualifying as "alternative systems" and the remaining population labeled "conventional agriculture," leaving the impression that most, if not all, of the systems not qualifying as alternative agriculture are not sustainable. Stripping the report to its essence, alternative agriculture rests upon the foundation of rotations, total nutrient management, integrated pest management, conservation tillage, and variety selection—all recommended components of conventional agriculture. Farm size and labor requirements are the major differences in alternative and conventional agriculture as outlined in the report.

REVIEW

The *Alternative Agriculture* report of the National Research Council (NRC) Committee on the Role of Alternative Farming Methods in Modern Production Agriculture had its impetus in reaction to the environmental impact of the nation's more than two million farms operating on one billion acres of the U.S. landscape. This farmland acreage constitutes two-thirds of the nonfederal land base in the United States with the cropland component amounting to about 420 million acres. This farmland acreage is a manipulated landscape with a variety of systems used in its harvest.

The essence of human sustenance is dependent upon the capture of solar energy through plant and animal biomass and the supplies and flows of nutrients. In favorable to moderately favorable habitats, hunting-gathering societies required 300 to 600 acres per capita, and much more in less favorable habitats, in order to obtain their daily ration of approximately 2,500 Kcal (Pimentel, 1989). Harvesting a terrestrial habitat in this fashion comes close to maintaining the integrity of natural ecosystems. The simple laws of nature dictate, however, that extracting a greater harvest from a terrestrial habitat to support more people requires the ecosystem to be changed or manipulated through the expenditure of greater amounts of labor and energy/resources. There are many alternatives as to how ecosystems can be manipulated and harvested. The equation relating harvested biomass to the necessary labor and energy/resources must be balanced.

As if this environmental framework were not difficult enough to balance, today's agricultural systems also must be evaluated within several other frameworks. These include: economic viability, including the disproportionate influence of government programs on risk avoidance and various commodities; social acceptance, including farmers' and consumers' lifestyles as well as food safety; and sustainability, i.e., the process of keeping up a standard within the environmental, economic, and social frameworks. Assessing a particular suite of alternative agricultural systems advocated by their practitioners must be done within the context of each of these frameworks. Furthermore, such an assessment must include a comparison of these alternative systems against the remaining population of agricultural systems, using the same frameworks.

The NRC report provides an excellent overview of the real problems facing U.S. agriculture today. These problems range from the environmental impacts of the various production technologies and by-products of these systems to the economic and social issues. The ramifications of these issues range from the problem of farmers being able to obtain an acceptable income from their labor and investment to the consumer's desire for a safe food supply while maintaining some level of cosmetic standard. The government role in all of this is well documented.

However, the subjective approach used in this, or any report, is fraught with the danger of being interpreted as conclusive evidence or legitimization of a movement or advocates of particular philosophies that, while mostly rooted in sound husbandry practices, have not been verified through established protocols. Despite qualified statements to the contrary, the report goes on extensively in places as if alternative agriculture were embraced as a proven, if not exclusive, option.

Another of the flaws of the NRC report is that the alternative systems are compared against the rest of the population of agricultural systems without emphasizing the spectrum and character of this population and defining the complex taxonomy contained therein. This approach results in a bifurcation, i.e., suggesting and/or inferring that conventional systems lack the capability of attaining environmental compatibility, economic viability, social acceptance, and sustainability, because they approach a concept of chemically dependent monocultures resulting in intractable environmental insults and a propensity toward a synthetic chemical residue-laced food supply.

The nature of the subjective assessment is also reflected in the case studies, even though limited data are presented for most cases. Because economic and social climates are subject to change, sustainability must take on the dimensions of flexibility, adaptability, and time. The report cites case studies where economic viability is predicated on premium prices for products. It would not take too many neighbors emulating these systems before this economic advantage was neutralized by market forces, thereby rendering these systems economically unsustainable.

The time necessary to assess sustainability within an environmental framework may be an order of magnitude or more than the time necessary to assess sustainability within an economic framework. Several years (or even decades) have been necessary to learn of the environmental impacts of some conventional practices. Therefore, we must be careful not to ascribe certain results, whether negative or positive, to alternative systems that may be carryover phenomena from conventional practices and vice versa. For example, the success of alternative systems that have not included fertilizers in years may be the result of mining carry-over fertilizer from conventional applications. One must determine how much, if any, of the fertility ascribed to a nontraditional practice is really a residue effect versus a result of the alternative practice. Fertility levels for certain nutrients in some soils may be tapped for decades before the response curve breaks downward with respect to yield. Likewise, studying a production system that does not use pesticides in the middle of a conventional farming area begs the question about the influence of current and past conventional production practices of its neighbors on the alternative system. Pests, including weeds, may take several years to adapt to an ecosystem changed through the introduction of alternative systems the same as they do in chemical-based systems. Alternative systems must operate over enough time to measure the influence of such systems. The report does not emphasize these points.

The case studies in the report cited weed control as the dominant production problem producers faced as they weaned themselves from herbicides. Like any ecological system, there are tradeoffs for each alternative. Cultivation requires time that may be taken away from other operations, such as the necessity to make hay during the optimum cultivation period. This also points out that one of the reasons herbicides are used is to reduce the risk of having very narrow or closed windows of opportunity because of wet weather when there is reliance on mechanical cultivation. And, of increasing importance, more farm operations have one or more persons employed off the farm, thereby reducing the opportunity and incentive for alternative weed control strategies. For other case studies, the weed problem was so intense that the producer incorporated the weeds as part of the hay biomass. The report never addressed the potential economic cost and environmental impact of this practice as viable weed seeds might become scattered through the transported hay, manure, animals, and machinery to other farms. Subsequent follow-up for several of the case studies indicates substantial changes in these operations, including one farm going out of business to the subdivider (Sabot Hill Farm in Virginia) and others having to increase their reliance on chemical inputs for economic sustainability (Gianessi, 1989).

I am of the opinion that our science-based agricultural research, development, and education system has served us well. It is not without shortcomings, as is any large undertaking and complex system. But, let us not bifurcate such a complex system and dissect it into labeled units, each with constituencies demanding attention and funding at the expense of the whole. An alternative system should not be assumed to have a higher regard for land stewardship or greater efficiencies than soundly designed and managed conventional systems. Any agricultural production system should stand the test of scientific scrutiny, economic analysis, and social acceptance and impact. American farmers should be offered technological menus from which they could select production technologies and strategies commensurate with their choice of lifestyle, motivations, and resources. These production systems should have known production potentials and economic benefits while being as socially acceptable and environmentally benign as possible. Government regulations and policies could be developed to foster such systems, a point made emphatically by the report.

The report also makes the point (page 137) that much of the scientific knowledge of alternative practices is based on research derived from the Land Grant/U.S. Department of Agriculture establishment. The report also points out (page 231) that scientific studies in progress for more than a century in England (Rothamsted), Illinois (Morrow Plots), and Missouri (Sanbourn Plots) have demonstrated the capacity of legumes in rotations to sustain high levels of grain production over long periods without nitrogen fertilizers. Likewise, the report emphasizes that the agricultural research establishment has for decades been researching and developing technologies and strategies that serve as the backbone of alternative systems. These technologies and strategies include: pest resistant/tolerant crop cultivars; integrated pest management; biological pest control; enhanced nitrogen fixation; nutrient management systems with precise timing, banding, split applications, and credits for legume and animal manures, as well as carryover nutrients; conservation tillage; rotations; cover crops; green manures; yield goal determinations from soil productivity indices; water management; seeding rates and plant densities/spacing; and timeliness of operations. Many of these production components have no cost associated with them, other than sound management. These agricultural husbandry practices are as sound today as they have ever been. But, the factors of social acceptance, including: the personal lifestyle choices of farmers (some do not want to be involved with animal agriculture); the propensity of most American consumers for cosmetically acceptable produce; the desire to reduce risk and labor; the necessity to provide options for off-farm employment; the desire for reduced management intensity while operating larger units; and the carrot provided by government programs all tend to drive farmers toward what is today called conventional practices. Without government intervention, American agriculture might look much different that it does today, perhaps tending much more toward what the report cites as alternative practices and systems.

As a scientist, I am interested in a level playing field. We must develop protocols for assessing environmental impacts of our production technologies and the long term effects, if any, of production resource residues in our food supplies. We also owe the consumer risk assessment data on residue levels as well as the risks, if any, of food produced without synthetic chemical resources. Paying a premium price for a residue-free or certified organic product should entitle the consumer to know how much risk avoidance he/she is getting for the dollar or how much, if any, other risk is being traded off as a result of buying products that may contain natural toxic compounds as a result of alternative production methods. Nature is not without its own biochemical processes that can manufacture all manner of metabolic residues, some of the constituents of which are known carcinogens. How can we provide risk assessment across the spectrum of the synthetic-natural chemical complex? The report does not address this issue.

Despite these shortcomings, I commend the NRC Board on Agriculture for their report. To review the broad concepts of alternative agriculture and case histories of specific examples across the broad spectrum of American agriculture is a herculean task. Clearly, advances in agriculture have not been the sole domain of scientists. Farmers, like other entrepreneurs, have among their population those who build upon and advance existing and new technologies. The approximately two million individual U.S. farm operations, each with its ecological uniqueness, coupled with managers driven by various interests, motivations, and levels of risk-taking, lend themselves to developing alternatives. This synergism of scientists and entrepreneurs has led to a U.S. food production system that is both bountiful and wholesome, although not without problems. The primary message in the report is the emphasis on sound husbandry practices, reaffirming the necessity to manipulate our global habitat with an emphasis on stewardship and sustainability.

From the large areas required to sustain our early hunting and gathering ancestors, we are at a point in time where the earth's more than five billion inhabitants must sustain itself from a finite food-producing dowry. This terrestrial dowry is now being tapped to sustain us at a ratio of less than one acre per capita in many areas of the world. It is obvious that this terrestrial dowry must be manipulated and perhaps expanded, although the latter option possesses the risk of greater environmental impacts. There are many alternatives from which to select. The choice should allow for any system based on the principles of science as scrutinized within the frameworks of environmental compatibility, economic viability, social acceptance, and sustainability. For most complex systems in our universe, there are no absolute choices—only intelligent alternatives, each with costs, risks, and benefits. We should not confine our alternatives as long as they can meet our goals and standards.

Literature Cited

Gianessi, L. P. 1989. The potential for alternative agriculture. Paper presented before 1989 State Affairs Conference of the National Agricultural Chemicals Association, Washington, D.C., Nov. 14, 1989. Resources for the Future, Washington, D.C.

Pimentel, D. 1989. Ecological systems, natural resources, and food supplies. Pp. 1-29, In D. Pimentel and C. W. Hall (Eds.). *Food and natural resources*. Academic Press, Inc., San Diego, California.

Comments on *Alternative Agriculture*

M. Scott Smith
Professor of Soil Biology and Chairman
Department of Agronomy
University of Kentucky

SUMMARY

The National Research Council (NRC) report is a valuable contribution to the debate on low input sustainable agriculture (LISA) and organic farming primarily because of the approach taken in defining and describing alternative agriculture. The discussion is based, not on assumptions about the inherent good of low inputs or the inherent bad of synthetic chemicals, but on more concrete and widely acceptable objectives: resource conservation, food safety, and farm profitability. In contrast to some popular press reports, the NRC does not recommend elimination of agricultural chemicals or total adoption of organic farming, but rather argues for policy and research based on the objectives above, and supports specific agricultural practices which, in many cases, should be attractive to both the general public and farmers.

REVIEW

The reaction of many farmers and agricultural scientists to the low input sustainable agriculture (LISA) movement has been, to say the least, skeptical. LISA is descended from the organic farming movement, which was even less widely accepted. The most recent evolutionary step, labelled *Alternative Agriculture* by the National Research Council (NRC), is clearly a new species. Those who take the time to read the NRC report may at last find a sound and rational basis for discussion and investigation of these issues.

Unfortunately, not many people actually read this sort of thing, most notably some of the journalists who prepared the reports and editorials about the NRC report. My local newspaper featured a cartoon of an addicted farmer shooting up with syringes of fertilizers and pesticides, and an editorial about "Farming the Natural Way." Readers were left with the conclusion that the NRC (the experts) had recommended elimination of agricultural chemicals and endorsed organic farming. Much of the agricultural community is, not surprisingly, confused and defensive.

Thus, it was a pleasant surprise to find that the NRC report contains a rational discussion of the issues. Perhaps the greatest contribution of the panel has been to provide a generally balanced and objective framework for what previously has been an emotional and subjective debate.

The most important example is the manner in which the report deals with the low input issue. During the organic era the central, but scientifically pointless, debate was natural versus synthetic or organic versus chemical. In the LISA phase, the focal point of contention has been the low input issue. We could all accept the value of sustainability. But to many of us, LISA was an oxymoron. How did low input come to be considered an inherently good quality of farms?

Part of the answer is certainly that low input is compatible with the values of the organic movement. But LISA's success (to the point of getting its own grant program), is perhaps based on the subjective application of ecological science. Most of us who have studied ecology probably have the feeling that stable and undisturbed ecosystems, such as native grasslands and virgin forests, are good. This is an aesthetic response, not something that is found explicitly stated in textbooks. At least in some ways these appealing systems can be described as closed, low output and low input. Thus, low input becomes associated with good, stable systems. If we then begin to think of farms as ecosystems, it is tempting to assume that low input farms are stable and good.

The difficulty is that low input and stable (or sustainable) are not always closely related in agriculture. Many farmers clearly have decided that they are not at all related economically. And many agricultural scientists have concluded that they are not well related with regard to resource conservation. Is it sensible to expect high output ecosystems to be low input? (And wouldn't low input sustainable suburbs have much more impact?)

It may, in fact, be reasonable to expect reduction of off-farm inputs, but only when this can be justified in terms of our real goals, which include resource conservation, a safe and stable food supply, and agricultural profitability. This is generally the approach that the NRC panel has taken. Alternative agriculture is defined in terms of these goals. LISA and low input for its own sake are generally abandoned. The closest the report comes to a low input endorsement is in listing one of the defining goals of alternative agriculture as "Reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of farmers and consumers." Omitting the last fifteen words would have made a big difference in this statement and in the report.

Most agricultural scientists and farmers should react favorably to the specific practices recommended in the report. These include: crop rotations; integrated pest management; control of weeds, diseases, and pests through management practices; conservation tillage; and genetic crop improvements for pest resistance and efficient nutrient use. The report clearly indicates that appropriate use of fertilizers and pesticides will continue to be necessary and valuable. The limitations, as well as the potential, of such practices as biological pest control and alternative nutrient sources are considered. (However, the potential is emphasized more than the limitations.) In fact, some agricultural scientists may wonder what is new in this agenda. My department has major, long-standing research and extension efforts on all of the practices listed above, and I don't believe we are unique in this.

The emphasis on systems-oriented research is one novel aspect of the report. However, the novelty of this may be more apparent to plant and animal scientists than to economists who can justifiably claim that economic analysis has always provided a valid and eminently practical means of analyzing farm systems. Research on crop and animal management practices undoubtedly would benefit from more practical interdisciplinary efforts. Also, this research should consider economic, environmental and sociological results as well as productivity results. Yet characterizing and comparing farming systems is often more difficult and expensive than dealing with a few variables in a factorial design.

Unfortunately, the NRC report does not provide, in the eleven detailed case studies included, a satisfactory illustration of how farm systems are to be studied and characterized. The case studies constitute one of the more prominent but negative aspects of the report. Undeniably there is much to learn from even non-quantitative study of working farms. Yet many agricultural scientists who felt that the organic movement relied extensively on testimonial data will be very uncomfortable with discussions of pest problems, yields, and economics, which are based on appearances, hearsay and the farmers' own observations.

Overall, the NRC report is fair, generally sound technically on agronomic issues, but probably unreasonably optimistic about the widespread applicability of alternative nutrient sources and pest control strategies. Hopefully, many farm leaders, agricultural scientists, and environmentalists will go beyond the newspaper headlines and read the report itself. If so, the NRC report may help to direct all of our energies towards shared and reasonable goals for agriculture: economic stability; conservation of soil, water, and fossil fuels; and safe, abundant, and affordable food.

Alternative Agriculture
A Concept We Cannot Ignore

Deon D. Stuthman
Department of Agronomy and Plant Genetics
University of Minnesota

SUMMARY

The committee responsible for this report is to be commended for a job well done. Their analysis of the subject is comprehensive. The four major

findings of the committee derived from that analysis appropriately set the stage for the entire report. The well documented information provided in the report is a useful resource and the conclusions, presented in the Executive Summary, are valid and are clearly supported in the body of the report. The recommendations made by the committee are reasonable and thought provoking. In their totality, these suggestions form the basis for a most useful and needed public policy debate on several issues relevant to the development of the next "Farm Bill."

REVIEW

There are several aspects of the report that will be especially helpful to people both in and out of production agriculture who wish to better understand this complex subject. One is that production systems are subdivided by primary products/geographic regions of the country. Such a categorization allows for more specific and accurate definition of the problems that need attention.

A second helpful item is the description of the general goals of alternative agricultural production systems. Considerable energy has been expended by many different groups in just trying to name, define, and in some cases, limit what is under discussion. Perhaps this list of goals will allow at least some people to move beyond definition and labeling and begin to provide useful suggestions and possible solutions.

Government policies and programs for agricultural commodities are examined for the consequences of their unintended effects, especially those which are, or may be potentially, damaging to our soil and water. Some features of the commodity programs are described as anti-conservation and many generally discourage adoption of alternative production practices. Specifically, the cross compliance provision in the current Farm Bill discourages crop rotations. High target prices and deficiency payments encourage inefficient use of purchased inputs in crop production. The arguments supporting these contentions are well made and warrant careful consideration.

The identification of an integrated research and extension agenda should be undertaken so that needed information on alternative production systems can be provided. This integration of factors important to more effective production systems is stressed as is the combination of crop and livestock systems. There is need for public funding of research for biological pest control because of lack of incentive for private industry. Finally, the committee correctly states that the transition to profitable alternative production methods may require additional time, resources, and skill of the producer.

The inclusion of 11 different case studies which describe both successes and difficulties is informative. These examples are illustrations of what can be done; however, some cannot be generalized because of their unique circumstances. The report also indicates what is required for these specific alternative systems to be financially viable. Because they are relatively more labor intensive and require considerable management skill and technical knowledge, these alternative approaches will not be attractive to many producers. Even those people who are enthusiastic and adopt the alternatives usually will not find them to be immediate successes.

In conclusion, the recommendations that specifically address commodity policies and farm programs warrant careful consideration. Specific program provisions that provide incentives for practices which can contribute to the contamination of our soil and water, or that deplete our groundwater, should be examined very carefully. This is especially true when these practices also result in greater production of crops already in surplus.

Alternative Agriculture Have We Been There Before?

Maurice E. Watson
Associate Professor and Head
Research-Extension Analytical Laboratory
The Ohio State University

SUMMARY

Alternative Agriculture proposes to replace, or dramatically modify, the conventional agriculture system. One problem with the report is a lack of definition for conventional agriculture. The report implies; without providing solid scientific evidence, that alternative agriculture is less detrimental to the environment than conventional agriculture. However, serious contradictions are evident in the 11 alternative agriculture cases cited. In addition, the common denominator for these cases is attributable to extraordinary managerial ability, use of specialty markets, and market development. With no realistic assurances, can we afford to gamble on alternative agriculture's capability to sufficiently provide for society's food requirements?

REVIEW

It appears that the primary purpose of the National Research Council committee's report on "alternative" agriculture is to propose and recommend that the alternative agriculture system replace, or dramatically modify, the presently used "conventional" agriculture system. The main premise of the committee seems to be that alternative agriculture is necessary in order to sustain agriculture production and provide greater protection to the environment. However, no solid scientific evidence is given to substantiate that alternative agriculture can accomplish this. A primary weakness of the report is that no definition of "conventional" agriculture is given, and the definition for "alternative" agriculture is nebulous, at best. The report implies that there is a specific ideology for conventional agriculture, and tends to ignore the concept of Best Management Practice (BMP) and the use of Integrated Pest Management (IPM), components of many conventional agricultural systems. Proponents of alternative agriculture seem to view it as a goal unto itself with very little concern for making absolutely sure that the high levels of agricultural production that we now have, and need, are maintained. The report contains the committee's opinions concerning the effect of past government agriculture programs. It appears that the committee blames these programs for the dearth of farmers using alternative farming approaches. However, the report fails to recognize that the government may be more interested politically in subsidizing the farmer to maintain low food prices rather than face the political fallout from the consumer over high food prices.

Environmental Concerns

The report emphasizes that alternative agriculture practices are not detrimental to the environment, however no scientific data is given to support this. Eleven farms were selected as case studies for this report, but not one well water sample was taken from these farms and tested for the nitrate concentration. This type of testing should be a requirement for any farm used in a case study supporting alternative agriculture. It is known that many waters which contain nitrates at the contamination level have manure and legumes as the nitrogen source. Furthermore, the report provides maps showing sites where high nitrate concentrations have been found in groundwater, but does not provide any information about the condition of the wells. It is known that deteriorated wells will allow nitrates into the groundwater. The committee report assumes that the application of manure to the soil is sound because it is natural—the nutrients are returned to the soil to be reutilized. However, applications of manure can often cause nutrient imbalances. A prime example is that potassium from manure can reduce the plant uptake of magnesium causing a magnesium deficient plant, especially in soils low in magnesium. It should be mentioned that in the case of the Thompson farm, the 18 tons/A application rate of sewage sludge/manure mixture is apt to be excessive for most normal fertile soil situations. Adding this much sludge/manure mixture possibly could cause elevation of the soil phosphorus levels as well as the heavy metal levels. However, no data are provided on the concentration of heavy metals in the sludge. It seems rather ironic that there is concern about polluting the environment of this farm with pesticides, but apparently little concern about polluting the soil with heavy metals.

Managing Ability

The common denominator in most of the alternative agriculture case studies cited is that the managers of most of these farms seemed to be extraordinarily efficient and had excellent ability to find fad markets (health food) or could develop markets where their produce would achieve premium prices. These types of markets would not sustain the American farmer on a large scale. In addition, some states have "organic" food regulating organizations that have the responsibility of certifying growers of "organic" food crops as organic farms. However, testing for pesticide residue or nitrate levels in the crops or soils is not required for a farm to be certified as an "organic" farm.

Crop Yields

Prior to the 1950s, many farms consisted of crops in various rotations. Crops were often corn, soybeans, alfalfa, sweet clover, red clover, wheat, oats, etc. Most of the farms also raised various animals, e.g., beef and dairy cattle, swine, poultry, and sheep. The animal manure was returned to the fields, rotations were followed, and usually fields were cultivated numerous times to control weeds. Thus, what now seems to be defined as "alternative" agriculture was "conventional" agriculture during that time. However, the advent of commercial fertilizers, especially nitrogen fertilizer, caused crop yields to increase significantly in most cases. Thus it became very obvious that the conventional agriculture of that day could not compare to the increased production and profits brought about by the use of commercial fertilizer. Furthermore, the report recommends that more rotations involving legumes should be used. A major difficulty with this is that if the land is producing a legume crop, it cannot be producing a food crop at the same time. This could be extremely important if our food supply should ever become less abundant. Possibly a goal of alternative agriculture should be high per-acre crop yields to ensure plenty of food for this country. The case studies given tend to show that crop yields produced by these alternative agriculture farms were slightly better than the average conventional farm in the same county in some cases. A more valid comparison would have been to compare the yields with those obtained from the top conventional farms in the same area. The ability of American agriculture to produce a surplus of food should be considered an asset rather than a liability.

Research

The committee's idea that greater knowledge of all variables and their interactions affecting agriculture production be attained is certainly a worthy goal. However, to develop research programs that can evaluate the multiple variables and their interactions is extremely difficult and very expensive, but has almost always been done. The committee mentions many of these variables and refers to them as "the natural system." However, the report fails to stress sufficiently the importance of the weather variable upon the natural system. The alternative agriculture system that might work well one year may be disastrous the next year because of weather. It should be pointed out that there is no constant natural system. It changes as the many variables do. In fact, humans are ultimately part of the natural system, and as a result can change and modify it to attain greater output.

Apparent Contradictions

Much of the information presented in the report from the case farm studies seemed to contradict the basic premise that natural systems should be utilized, i.e., inputs of pesticides and "synthetic" fertilizers should not be used. However, most of the case study farms did use some pesticides and "synthetic" fertilizers. Furthermore, the alternative agriculture concept embraces the idea that the system should be economically and biologically sustainable—essentially be a closed system. However, in one of the case studies an off-farm nutrient resource (municipal sewage sludge) was obtained free of charge. Another case study indicated that the alternative agriculture used was not sufficiently profitable, requiring the wife to obtain off-farm employment. Labor is another important input of the alternative agriculture system. If the case studies are realistic examples of this kind of agriculture, then it would appear that the labor requirements are very high for the size of the farming operation. Furthermore, it appears that off-farm labor must be found to add to the system to take care of the back-breaking work such as hand weeding fields. The alternative agriculture approach essentially opposes the use of herbicides. Consequently, extensive cultivation is required to eliminate weeds. The report indicates that more soil erosion takes place when cultivation is used. However, an important goal of alternative agriculture is to minimize erosion. Therefore, it is very difficult to understand how this kind of agriculture can have it both ways.

An Important Alternative Agriculture Tool

It is interesting to note that one of the case study farms did not believe in testing the soil for its fertility level. This is quite surprising since soil testing is a very important management tool that has been used by farmers for over 50 years. Soil testing can be especially useful to farms that have animals to determine if too much manure (as fertilizer) is being added to any specific field. Often this is found to be the case, rather than over-fertilization with synthetic fertilizers. Usually the proper management of nutrient application is much more likely to occur with synthetic fertilizers than with animal manures.

Rather than promote an agriculture production system that essentially was in use 40 years ago, it would seem more logical to use the modern technology and management practices available for the needed agriculture production and environmental protection. More energy and funds should be directed to research that can provide better technology. A few examples of needed research are the development of better pesticides, development of pest and disease resistant plants and animals, development of appropriate BMP's to meet the individual farm environmental situation, and the evaluation of relative risks to human health by synthetic chemicals in comparison to toxic chemicals that exist in nature under "natural" agriculture systems.

7

Economics and Sociology

The Three R's of Agricultural Sustainability: Reality, Redirection, and Restraints

Harold O. Carter
Professor of Agricultural Economics
and Director of the Agricultural Issues Center
University of California, Davis

SUMMARY

Change in the direction of a reduced-chemical agriculture is underway; the only questions are how fast and by what means. Two possible approaches involve technology and fewer off-farm inputs ("sustainable" agriculture). These approaches can complement each other. Barriers to the changeover include: (1) lack of knowledge about reduced-chemical systems; (2) marketing uncertainties; (3) federal farm programs; and (4) potential impacts on the world food supply. Sudden, mandated changes in farming systems could impede progress and increase public and private costs. On the other hand, appropriate incentives in research, in education, and in government support would hasten the changeover.

REVIEW

The question is not whether we will move toward a reduced chemical agriculture but how fast will the move be made, and by what means.

Clearly, farmers would prefer to use fewer chemicals if they were given a reasonable choice; but, in addition to human inertia, there are many very real obstacles to change. As pressures grow, particularly those stemming from environmental concerns, these barriers will be overcome.

For some time into the future, various agricultural systems—including conventional energy-intensive systems—will operate side by side. Meanwhile, successes with new methods and new technologies will be forthcoming. Thus, an era of new, more sustainable agriculture will eventually evolve, but not over night or even next year.

Appropriate incentives in research, in education and in government support will hasten the approach of this new era. On the other hand, ill-conceived, sudden mandated changes would likely impede meaningful progress and increase both private and public cost. Also, a retreat by farmers from high levels of chemical use may require more incentives than those envisioned in the National Research Council's 1989 report *Alternative Agriculture*.

Nevertheless, the need for change is apparent. Agriculture is under increasing pressure from many directions to critically examine the effects of intensive farming systems—especially effects on the environment, but also on rural communities, worker health, food safety, and even producer profitability. In addition, despite impressive gains since World War II under the current agricultural system, the rate of increase in food productivity in developed countries has been diminishing.

Meanwhile, some farmers are questioning the cost-effectiveness of certain modern practices. For example, in California, costs of pesticide purchase and application for specialty crops may be as much as 20% of total direct costs for a season. Also, a very serious problem is the increasing resistance of pests to chemicals that have worked well in the past.

The solution proposed by some has been to change current chemical intensive farming practices to "sustainable systems." What will such systems to solve the environmental, health, resource, and production problems that confront conventional agriculture look like? At present, two major directions appear to be developing. One is a refinement of present high-tech methods, including computerization, to reduce chemical based inputs through increased management capability. The second also relies on increased management capacity, but attempts to replace purchased off-farm inputs with those produced on the farm through the biochemical and physical processes native to the farming system itself.

Obviously, these two approaches are not mutually exclusive. In fact, the technologies that are developed in either system can benefit both. Computerization is a natural ally for the systems approach that is basic to alternative agriculture. Computers can help model systems, and they can enable labor-saving mechanization of weeding and other operations that replace chemical use. At the same time, alternative agricultural research can be a valuable input to high-tech agriculture since a systems understanding of plant and soil processes can lead to development of more effective, but less toxic, chemicals and means of application.

One example of a system that includes elements of both alternative agriculture and computer-based technology is Integrated Pest Management (IPM). And—important for widespread adoption—IPM practices are usually profitable, particularly when properly applied to cropping systems and regions where high rates of pesticides are normally used.

What are the barriers to new "sustainable" production methods? Probably foremost is lack of knowledge about reduced chemical systems. The number of well designed, empirically replicated experiments on sustainable farming systems is very limited, compared to those on conventional methods. Farming practices in the eastern and midwestern United States have received the greatest attention, with relatively little work on crops in the irrigated West. An important point is that requirements for any farming system, including low-input farming, vary between countries, between regions, and even from farm to farm. Much of the research so far on sustainable farming systems is based on case studies which are only suggestive of possible outcomes. The highly publicized National Research Council's report, *Alternative Agriculture*, illustrates this point. Its several case studies are encouraging, but far from generally applicable.

From a farm manager's viewpoint, there is a natural reluctance to deviate from what has worked successfully in the past. There is considerable risk involved in converting to an entirely different production regime, especially one whose average profitability must be measured over a multiple-year crop rotation cycle. Also, what works one place may not work in another. Yields may be lower; quality may be less. If farmers choose (or are forced by regulatory or other pressure) to switch abruptly from chemical-intensive to certain low-input farming methods, their yields most likely would decline sharply, at least initially. The variability of yields (and income) very likely will be greater with alternative systems, especially in the transition period.

The change to alternative agriculture does not just involve the production system, but also marketing. Farmers must grow what will sell. Will consumers accept less than cosmetically perfect fruits and vegetables? A University of California, Davis agronomist estimates that a system relying solely on biologically fixed nitrogen would require a 1:1 ratio of acreage planted to nonlegumes and legumes. Who will buy all the beans or forage produced by these systems? What will be the effect on established domestic and export markets for the other crops?

There are also a number of institutional constraints to moving to alternative production systems. One is the orientation of research and training in our land grant institutions. Over the past several decades, the focus has been on intensive, high energy-input production techniques. Research also has long been oriented toward increasing yields under conditions of relatively expensive labor. Research in new methods is in its infancy; formal training in using them lags even further.

Another institutional constraint is that federal farm programs, originally conceived almost six decades ago, constitute a formidable barrier to alternative agricultural systems. Price supports for a particular crop are tied to farmers' base acreage in that crop, which is determined by their recent production history. This feature has encouraged high chemical use and monoculture—an entirely different system than those that will characterize alternative agriculture. There are, however, preliminary signs of change. The Conservation Reserve Program in the Food Security Act of 1985 that promotes acreage retirement of fragile lands is consistent with environmental goals of sustainable agriculture. More of this sort of encouragement is expected in the 1990 farm bill. But as long as federal farm program benefits are offered in basically their present form they will work against movement toward a different production system.

Finally, besides these farm level and institutional constraints, there are a number of broader considerations. Most basic: Could the world's burgeoning population be adequately fed if all agriculture turned away from chemicals? Or will "factories in the fields" producing great volumes of food and fiber with the aid of judicially applied chemical inputs always be needed just to keep up with the increasing number of mouths? Here again, risk assessment is important. Lester Brown warns us about the precariousness of world food stocks related to drought; global warming, and erodible lands as well as dwindling nonrenewable resources. Inventories of grain now are close to their lowest levels in modern history. What are the global ramifications of a rapid conversion to a production system possibly with greater year-to-year variability? Obviously we need a careful assessment of the balance between societal gains and losses. The stakes are high.

Now that at least some of the constraints and risks have been listed, necessary new directions for research, education, and policy become clear. First, public and private research must shift from its emphasis on input-intensive, yield-increasing production to include investigations of sustainable farming methods. Incentives are required to encourage multidisciplinary research and extension in these new areas.

More than just farmer education is needed. The public must become more literate about modern agriculture. Consumers need to understand why changing farm practices takes time and money; and they must recognize that cosmetically perfect, low-cost fresh produce may be scarcer in a reduced chemical environment.

Simply mandating social change through regulation and law can be counterproductive. The impacts of any regulation usually extend far beyond its intended purpose. When farmers are more knowledgeable about and less reluctant to try new methods and when the public understands their difficulties, then acceptable compromises may be reached.

In some cases when inertia or economics inhibits change, government incentives may be required to provide sufficient motivation. Such a policy move makes sense, given the facts that (1) sustainable agriculture's benefits eventually accrue to all of society, and (2) at least initially, farmers will pay the costs of change to sustainable practices.

Comments on *Alternative Agriculture*

Michael D. Duffy
Associate Professor, Extension Economist
Iowa State University

SUMMARY

Alternative Agriculture presents a means, not an end. It advocates a means toward a profitable and more environmentally sound agriculture.

The book does not advocate eliminating chemicals, nor does it propose giving up science and technology. *Alternative Agriculture* advocates a more balanced approach to agricultural production recognizing that external

benefits and costs do exist.

Alternative Agriculture was a massive undertaking attempting to look at all aspects of agriculture and possible future directions. By its nature, it will not be universally accepted and will go contrary to those wishing to maintain the *status quo*.

REVIEW

The book, *Alternative Agriculture*, was a massive undertaking attempting to assess past, present, and possible future options for agriculture. This book was written by an interdisciplinary team over several years. Any assessment of directions written in this way will have statements over which there is sharp disagreement. The important contribution of this work is not the precise recommendations, but rather the broad message they convey.

These comments will not focus on the words of the book *per se*, but rather on the message and controversy it has generated. Agricultural production must be flexible. For example, corn fertilization practices should not be the same with low corn and high nitrogen prices as with high corn and low nitrogen prices. Such adjustments are basic economic logic.

As noted in the Executive Summary, "The hallmark on an alternative farming approach is not the conventional practices it rejects but the innovative practices it includes" (page 3). *Alternative Agriculture* is advocating less chemicals as a means to respond to health, environmental, resource use, and profitability concerns.

One of the biggest misunderstandings is that *Alternative Agriculture* is advocating organic farming. This is not the case. The definition of alternative agriculture on page 27 does not even mention the term.

Yet, this misrepresentation persists and is fostered by some media who thrive on controversy. One environmental group has been critical of *Alternative Agriculture* because policymakers might make hasty decisions to ban pesticides. Nowhere in the book does the committee advocate total removal of pesticides.

Another common misrepresentation of *Alternative Agriculture* is that it means giving up science and wanting to forget what we know about agriculture. Nowhere does this recommendation appear in this work. Rather, what appears is a quest for even more appropriate technologies to replace those that have proven to be extremely detrimental to the environment. Also, there is a quest to rely less heavily on the external resources and recycle more of the valuable internal resources whose potential may no longer even be considered.

Alternative Agriculture is moving back towards the time when agronomic principles and sound animal husbandry dictated our practices. Technological advances in machinery, pesticides, and fertilizers have all been geared toward allowing continuous row cropping. As a result, we try to farm every acre as if it was identical—regardless of the slope or inherent productivity of the soils. *Alternative Agriculture* is making the most appropriate use of technologies that exist, developing new technologies that are environmentally benign, and technologies that can be site-specific.

Alternative Agriculture has been criticized because of the case studies it used, but case studies had to be used due to a lack of systems research. Our investment in research has not kept pace with inflation, and our stations have a difficult time assembling interdisciplinary research. The focus of our agricultural research is continually being narrowed. Our projects learn more and more about less and less. We are extremely advanced in understanding the pieces, but we are woefully lacking in integrating the whole. The case studies used were examples of farming systems research needed.

Much of the controversy is about the economics of *Alternative Agriculture*. Here are a few points that must be made.

Economics is not the study of money—it is the study of scarcity and how we allocate our resources. Farmers must make decisions based largely on the dollars and cents. They must be market efficient. Policymakers, and those wishing to contribute to limit chemical pollution, recognize nonmarket benefits and costs. Market efficient agriculture is not also nonmarket efficient if there are external costs or benefits. If nonmarket costs are important, then they must be recognized.

At the farm level, many of the practices espoused in *Alternative Agriculture* are already in practice. The 1989 Iowa Farm and Rural Life Poll asked farmers the extent they used 11 different practices to reduce chemical or fertilizer use. There were four possible responses ranging from "not used" to "heavy use." In ranking the respondents, a farmer using none of the practices received a score of 11, and a farmer using all the practices received a score of 44. The average farmer's score was 24, and the distribution was bell shaped. This indicates that most farmers are using some practices to reduce input use. *Alternative Agriculture* is trying to get all farmers to think about input use and the substitutions possible.

Manure is a source of crop nutrients. When farmers do not have to realize the true cost of commercial nutrients (resource depletion, pollution, transportation, and production risks), then there is a tendency to dispose of the manure and purchase commercial crop nutrients. Manure varies in nutrient content and quality. Additionally, manure handling is not a pleasant task. If the nutrient value in the manure is less than its commercial counterpart, then the manure will be viewed as a waste product to be disposed of and not an intermediate product to be recycled.

Weed management is another farm level decision area addressed in *Alternative Agriculture*. The basic message is that we must begin to think of the problem as weed management, not herbicide management. Several studies show the efficacy and profitability of mechanical and cultural weed management techniques. Even in continuous corn and a corn-soybean rotation, herbicide usage can be cut by as much as two-thirds by banding rather than broadcasting the material. Such savings can be made with little or no changes in current practices.

Soil testing to determine nutrient needs is another management technique advocated by *Alternative Agriculture*. Phosphorous (P) and potassium (K) are two of the essential crop nutrients for corn and soybeans. A proper soil test can tell the level of these nutrients available for plant growth. Data from the U.S. Department of Agriculture indicate that over the last ten years, Iowa farmers have been applying P and K at levels consistent with crop removal.

The P and K application to Iowa soils appears to be efficient on the surface. However, this ignores the manure contribution of P and K and, more importantly, it ignores the levels of P and K that are already available in the soil. Approximately two-thirds of the soil samples sent to the Iowa State testing lab test high to very high in P and K. Test plots at the university research centers clearly show that applying removal rates to soils high to very high in P and K is not profitable.

This listing of comparative economic assessments could go on, but suffice it to say that many of the ideas espoused in *Alternative Agriculture* are not new. The profitability of the substitutions will depend on the individual case, and which costs and benefits have to be recognized. A critical evaluation of the options and all benefits and costs is the concept behind *Alternative Agriculture*.

The government programs and policies provide tremendous incentives and disincentives to farmers. *Alternative Agriculture* points out some of the features which cause increased use of chemicals and synthetic fertilizers. Policymakers must be aware of the unintended results of the policies they enact. This work shows that we must become more creative in our use of policy instruments. Market failures require government intervention. How we intervene is the critical question.

Alternative Agriculture is not advocating one set of practices for all farms. Instead, it advocates a balanced approach by evaluating all options and recognizing the strength and limitations of the physical and human resources available. *Alternative Agriculture* is not an end, but a means. A means to carefully evaluate our options, make the best use of existing technologies, and develop new and more environmentally sound technologies.

Alternative Agriculture

Cornelia Butler Flora
Department of Sociology
Virginia Polytechnic Institute and State University

SUMMARY

Alternative Agriculture lays out the policy constraints that make high input agriculture profitable in the United States. Given other pricing systems and given different sets of government-imposed regulations, low input agriculture would be comparatively more profitable and less exploitative to the soil and water quality. As the constraints change from government-imposed land and crop limitations, new technology must be developed to keep American agriculture profitable and competitive. The public sector must be highly involved in the research necessary to develop that technology. Alternative agriculture does not mean simply eliminating current chemical inputs, but requires extensive technology development in order to substitute cultural practices and management for high levels of chemical inputs. Chemicals will not be limited entirely, but levels will be reduced. Further, the rationale for low input lies not in food safety, which is high, but in maintaining environmental quality.

REVIEW

This is a radical book. It examines the roots of the agricultural research/production enterprise in the United States. In that examination, we learn that many assumptions about what are economically determined constraints of agriculture production are in fact politically determined constraints. As such, they can—and, the National Research Council suggests—will be changed.

Much of the technology that has been developed in the United States in the last 50 years has been aimed at increasing the productivity of a single crop on a finite amount of land. The authors make clear that this technology development has made sense within the limitations of federal policy that were set up as emergency measures in the depth of the Great Depression. The expense of current agricultural policies, including disaster relief, commodity programs, and other federal initiatives that lock farmers into certain crops on limited acreages, are increasing markedly. These costs include direct government payments and indirect environmental impacts. Just as the farm crisis of the 1980s changed the rules of the game for farmers and favored those who were able to manage capital better, the debt crisis facing the U.S. government in the 1990s (as much as concern over environmental problems of agricultural chemicals) will cause a shift away from the subsidized incentives for intensive monocropping and favor those farmers whose management practices include crop rotations, mixed cropping systems, etc.

The new managers—and researchers—of the alternative agriculture will, like their predecessors, develop farming practices to overcome identified constraints to production and profit.

While the assumptions behind the research and practices will be different, the actual practices of alternative agriculture will be based on many of those currently in use. Breeding for pest resistance will continue. Integrated Pest Management will increase. But, once the politically-imposed constraints of having to maintain base acreages as a mechanism to reduce risk are removed, pest and fertility production constraints can be addressed with a variety of cultural practices, including fallow and crop rotations, that are unavailable under the current rules of the game.

The alternative agriculturalist is one with a high awareness of the agronomic and economic systems in which production takes place. Just as the successful nonagricultural business is flexible and market oriented, so will the successful farmer of the future reduce risk by flexibility and diversity, rather than by dependence on federal programs. Alternative agriculture pushes the level of risk firmly to the level of the enterprise, arguing, along with the Reagan and Bush administrations, that markets, rather than governments, should determine what is produced. Once the government withdraws as the absorber of risk, those agricultural enterprises that survive will radically change their production strategies in order to reduce risk. The hope of the authors of *Alternative Agriculture* is that agriculturalists will take a long term risk reduction strategy and include environmental as well as economic risk in their calculus. Removal of the current safety nets for agricultural producers, represented by disaster relief and commodity programs, would increase diversification and reduce the use of high-cost inputs, but would not necessarily directly address the problems of non-point pollution. Regulation and education will have to be part of the policy environment for alternative agriculture to be both profitable and environmentally sound. The authors make a cogent argument that current federal policies, including commodity programs, trade policy, research and extension programs, food grading and cosmetic standards, pesticide regulation, water quality and supply policies, and tax policies reduce farmers' choices of technology and militate against the implementation of alternative agricultural practices which would provide better long term protection of the resource base. A wide range of changes at the federal level must take place for such alternative technologies to be profitably adopted and for research systems to systematically address the development and refinement of such alternatives.

Alternative agriculture does not mean the absence of purchased inputs or the return to mule-drawn plows. And alternative agriculture is not low technology agriculture. As described in the research review and the case studies, alternative agriculture substitutes management for capital and employs technological innovations that depend more on management than on the technology by itself. As occurred during the agricultural crisis in the 1980s, the alternative farmer will be an innovator and a highly skilled individual. Further, there will be increased interaction with other highly skilled specialists, including the providers of integrated pest management. The difference between hiring an integrated pest management scout and simply doing preventative pesticide application is not only a monetary savings, but a greater capture by the local area of the technology investment made.

Alternative Agriculture argues that much of the necessary knowledge is available for the implementation of alternative practices. However, the systematic research has not been undertaken that would allow the integration of that knowledge into practical solutions for farmer problems. Since the kind of technology to be developed would not result in an immediately capturable profit, the role of public sector research to develop such technological integration is key. The report does not address the internal constraints within the public sector that must be overcome for this kind of integrated, interdisciplinary research to take place.

This is an extremely important book. It makes clear that agriculture is not context-free, but highly dependent on both the natural and political environment. Research activity that reduces costs, protects health and environmental quality, and enhances beneficial biological interactions and natural processes is not antithetical to current activities of Land Grant institutions, the U. S. Department of Agriculture, or even the private sector. But substantial reorganization and reorientation will be necessary at the research and extension level, as well as the public policy level for alternative agriculture to be widely adopted. Most crucial, the policy climate will have to change dramatically for alternative practices to pay not only in premium prices because low-input products are so unusual, but because the public sector is now subsidizing practices that emphasize monoculture and the high use of inputs to solve the production problems it generates. Certainly alternative agriculture will be resisted as an idea by those content in their disciplinary boundaries and those who want simple answers to complex questions. However, changes in government policy, motivated by concern for debt rather than concern for the environment, may make such alternatives much more appealing in the near future.

Comments on *Alternative Agriculture*

Leonard P. Gianessi
Fellow, Resources for the Future, Inc.
Washington, D.C.

SUMMARY

Most of the growers profiled in the National Academy of Sciences (NAS) case studies use pesticides. In some cases they rank among the highest users of pesticides in the country. The Executive Summary of the report and the media interpretation of the report emphasize how these growers have been able to reduce certain pesticide uses. However, these farms also illustrate the value of using pesticide. Using herbicides for weed control is a necessity for most of these farms. The NAS studied these farms in 1986. In certain cases, the use of pesticides on these farms has risen since then in order to respond to new pest problems.

REVIEW

The National Research Council (NRC) report on *Alternative Agriculture* describes 14 operating farms where the use of pesticides has either been eliminated or reduced. Most of these farms still use pesticides. These are not, for the most part, purely organic operations. So, there are two ways of looking at these farms. First, it can be emphasized that they have reduced or eliminated pesticide use and that, as a result, they have made the environment better. This is the popular interpretation of the report in the media and on Capitol Hill. This view also receives the emphasis in the Executive Summary to the report. The second way to look at these farms is to emphasize that no matter how hard they try to reduce use, many of them still use pesticides. The reasons for their continued reliance on pesticides have not been described in the media nor in the report's Executive Summary.

The NRC report has been criticized for including only 14 operating farms as case studies. I am not one of those critics. In fact, I think that having studied 14 operating farms in detail during a single year is an outstanding achievement. There are plenty of details about each farm that are extremely useful in helping to resolve policy questions. I have a sneaky suspicion, however, that not too many readers have immersed themselves in the details of the case studies. I am going to describe ten of these farms in terms of what has been involved in reducing pesticide use and why they still use pesticides. For the most part, I am going to quote directly from the NRC report.

My thesis is that these farms illustrate the value of using pesticides; they illustrate some of the potential tradeoffs—both economic and environmental—of alternatives to pesticides; and they illustrate some of the potential constraints on policies that would attempt to lessen pesticide use.

One of the case studies is of four farms that use Integrated Pest Management (IPM) techniques in Florida's fresh market vegetable production. As the NRC report makes very clear, these four growers use substantial amounts of pesticides—for example, they use 180 pounds of methyl bromide per acre per year. To put this use in perspective, Illinois corn growers use three pounds of herbicides per acre per year; Mississippi cotton growers use ten pounds of insecticides per acre per year. The four Florida vegetable growers studied by the NRC report are some of the heaviest users of pesticides in the country. In addition to methyl bromide, they regularly use insecticides and fungicides. It is not made clear how much of these pesticides are used.

What does the methyl bromide do? Florida growers cover their fields with plastic, inject methyl bromide as a gas beneath this plastic, and this gaseous pesticide sterilizes the soil; it kills weed seeds, soilborne insects, and soilborne diseases. It is a very powerful synthetic organic chemical. Why did the NRC report include these kinds of growers in a report on alternative agriculture?

They have managed to successfully reduce certain types of pesticide use with alternatives. For example, for weed control, they have almost entirely eliminated the need for herbicides through the use of plastic mulch. They cover the field with the plastic, inject the fumigants, and plant tomatoes through holes punched in the plastic. Weeds cannot get through the plastic. They are smothered, and herbicides do not have to be used. One troubling aspect about the NRC report, however, is that no mention is made about what happens to the plastic. A new sheet of plastic without holes or rips has to be used every year. The plastic is disposed of by burning in the fields or in landfills. They have also started some recycling of the plastic. I am not saying that disposing of an acre of plastic in a landfill is better or worse for the environment than using three pounds of herbicides per acre. All I am saying is that from a public policy perspective, this tradeoff needs to be considered and the report does not mention it.

The Florida vegetable growers have also used some alternative methods to reduce annual insecticide use. They use scouting services to monitor fields, and they spray insecticides only when damaging thresholds are exceeded. Using these methods, by 1986 they had managed to reduce insecticide use by 21%. The NRC report case study was for 1986. What has happened since 1986?

In 1988, Florida tomatoes began to experience an irregular ripening disorder. A prime suspect for this disorder was the sweet potato whitefly which fed on the tomato plant and weakened the plant in some way.

Thus, in 1988, according to an IPM report for Florida, there was an increase of 20% in the use of insecticides in Florida IPM programs for tomatoes to handle this pest. These very same growers who are given credit for reducing pesticide use up to 1986 had to turn around and increase use in 1988. If 1988 had been the benchmark year, these growers would have appeared to have made almost no progress in reducing insecticide use with IPM. They have not been able to sustain their reduced insecticide use.

Another National Academy of Sciences (NAS) study involved IPM as practiced in California processing tomato acreage, the Kitamura Farm. These growers have significantly reduced insecticide and fungicide use through various techniques such as scouting for pests. They also benefit from their location, it hardly ever rains in the summer, and insects and plant diseases do not have much of a chance to flourish.

The NAS also calls attention to another key factor of this successful IPM program, good weed control. Good weed control makes it possible to keep disease and insect pressures low. There is no weed habitat for insects or pathogens.

When it comes to the Kitamura Farm, there is a straightforward description of how they achieve weed control through the use of herbicides. There is no discussion of any alternatives, such as cultivation, hand pulling of weeds, or the use of plastic. The NAS does not provide any estimates of how much of these herbicides are used by the Kitamuras. Their use is almost taken for granted.

One purely organic operation described in the NRC report is the Lundberg experimental rice 100 acre operation in California. According to the NAS, Lundberg tried to produce organic rice for 18 years and lost money in 17 of those 18 years. Occasionally, the loss was as high as $50,000 a year. In 1985, he made a profit, while in 1986, the year of the NAS study, it was unprofitable again. What are the key performance indicators?

His yields are about 50% lower than from rice acres treated with pesticides, and his production costs are about 40 to 50% higher. Success is based on a marketing strategy that persuades enough consumers to pay a 50% premium price to cover the higher costs of producing organic rice. Those are real costs, and those are real yield losses. He has tried organic growing for 18 years, and that is what he has achieved.

Why is it so hard to grow rice without pesticides? The problem is primarily weeds again, particularly barnyardgrass which infests 100% of the rice growing region of California. Rice acres with good barnyardgrass control show up as bright green, while poor barnyardgrass control results in yellow areas, indicating that the rice is overwhelmed by the weed. One policy implication from the Lundberg experimental farm data is to recognize the importance of herbicides in rice production. If you are concerned about the supply and cost of rice, one suggestion is to make sure that rice herbicides are available for the foreseeable future.

The Kutztown Farm is a Pennsylvania farm that is one of the most prominent alternative agricultural farms in the country. This farm surrounds the Rodale Research Center. The farmer manages each of 98 plots separately. He grows small grains, hays, corn, and soybeans. He feeds his own livestock. From a management standpoint, there are two basic parts to the farm. Land is rented from Rodale, and the farmer has agreed to not use any pesticides on this Rodale land. The farmer also has his own land, and he also rents land from other neighbors as well. On these acres, he manages according to his own rules.

During the time period 1978 to 1982, the farmer applied herbicides to the corn and soybeans on the non-Rodale part of the land. However, in 1983, he stopped applying herbicides to the soybeans while he continued to apply herbicides to the corn. To put it very bluntly, one of the most prominent alternative agricultural farmers in the country is using atrazine, the herbicide that is being detected most frequently in groundwater. Why doesn't he use an alternative method? The NAS report is silent on this question.

The answer is in a Rodale report describing the farm. The use of the herbicides frees the farmer from the need to cultivate weeds at a time when he should be cutting his hay crop. Since he is so busy managing all these different fields, he has to make a choice as to whether to harvest the hay crop or cultivate to control the weeds in the corn. The problem for this farmer really is the need for more labor.

There is a problem with the yield data for the Kutztown Farm. Yield measurements from this farm are cited by the NAS and many others as evidence that alternative agriculture works as well as conventional agriculture. As you can see, soybean yields at the Kutztown Farm cited by the NAS exceeded Pennsylvania averages for the years 1978 to 1982. These yield estimates were made by Rodale and Penn State researchers and published in their reports. However, these yield measures are for the whole farm, the Rodale and non-Rodale land considered together. The farmer used herbicides in the corn and soybeans on his own land in 1978 to 1982. This yield comparison cannot be used to support any claims of performance without chemicals, because chemicals were used on a portion, perhaps the major portion, of the corn and soybeans on the Kutztown Farm during this period.

How are yields doing since he stopped using herbicides in the soybeans? It turns out that the Rodale Research Center stopped making yield estimates for this farm in 1982. As a result, there are no data on how well the grower has been doing without using herbicides in his soybeans.

The yield data for 1986 would be particularly interesting to see. The NAS states that the farmer had a terrible problem with weeds in 1986. It was wet, and he could not get his cultivation equipment in to control the weeds. No yield data for 1986 are presented in the NAS report, even though that was the year of their case study.

The Sabot Hill Farm is located outside of Richmond, Virginia. When new owners—the Fishers—took over the farm, they decided to stop using the herbicide EPTC to control johnsongrass, a weed in soybeans. They continued to use EPTC to control johnsongrass in their field corn—in fact, they increased pesticide use by adding atrazine as part of the herbicide treatments for corn.

For soybeans, the Fishers decided to take their chances with no use of herbicides. If the johnsongrass was not too much of a problem, they could harvest a cash crop of soybeans. If the johnsongrass was a problem, they could harvest the johnsongrass along with the soybeans and just feed the entire crop to livestock.

However, the NAS report does not provide any data on how many soybean acres are harvested as a cash crop and how many are harvested as a hay crop. The case study does not provide any quantitative information on how often soybeans are not planted because the weeds are really bad. There is just a general absence of data for this farm. Only general statements are provided. However, further discussion about this farm is really moot. As I understand it, the Sabot Hill Farm is no longer in operation. The land is being subdivided for housing.

The Stephen Pavich grape operation in California is a clear success story. This operation produces about 1% of total United States table grape output. A very large percentage (greater than 90%) of the farm's acreage is certified as organic, meaning no synthetic organic chemicals are used. He uses no herbicides for weed control, and only very rarely has to apply any insecticides. How does this system work?

The key is that Pavich maintains a permanent cover crop of perennial rye grass down between his rows of grape vines. That permanent crop suppresses weeds naturally. The grass grows in the winter and is cut to provide a mulch that smothers weeds. He does not need to use herbicides to kill weeds. The grass crop also provides a habitat for predatory insects that then feed on insect pests so that Pavich does not have to use any insecticides. This is a very good example of alternative agriculture. What is the hidden cost?

The cost is the need for more water. According to the NAS, Pavich used three to five acre-feet of water per year in his California vineyards. Growers who irrigate only around the grapevines use two acre-feet of water. Pavich's farm is in the middle of a desert. Very little rain falls; the grass crop needs water. Most new grape orchards in California try to minimize water consumption through drip irrigation down the grape vine rows. They keep the middle of the rows bare. They use herbicides and insecticides. Pavich does not use these chemicals, he uses more water. It is a tradeoff.

When it comes to disease control, Pavich uses sulfur exclusively. Sulfur is a pesticide. Spraying sulfur on grapevines controls diseases; it is a pesticide. However, since sulfur occurs naturally in nature, its use as a pesticide is sanctioned for organic growers. The NAS is not very specific in quantifying how much sulfur Pavich uses. They only say that he makes several applications a year.

Pavich recently provided the University of California with estimates of how much sulfur he uses. He uses five to 12 pounds per acre per application. With seven to 14 applications per acre per year, Pavich typically uses about 100 pounds of sulfur per acre per year. Pavich is an organic grower using 100 pounds of a pesticide per acre to control plant diseases.

What are the alternative fungicides? There is a set of five newly-registered fungicides that control the same grape disease as sulfur does: powdery mildew. These new synthetic chemicals are used in terms of ounces per acre: one-half of an ounce per acre in some cases. I am not saying that using one-half of an ounce of one of these newly-registered compounds is better or worse for the environment than using 100 pounds of sulfur. I simply want to pose the following question: Who is the low-input grower? Pavich, who uses 100 pounds of the pesticide sulfur, or a grower using one-half of an ounce of a synthetic chemical? To be certified as an organic grower, none of the synthetic chemicals can be used, and the enormously higher rate sulfur has to be used.

Another NAS case study was of the Ferrari farm, which uses IPM in the production of walnuts. First generation codling moth larvae bore through the blossom end of the walnut and feed on the developing nut. This is the key pest of walnuts grown in California.

The IPM program for walnuts in California relies on careful monitoring with traps. If treatment can be timed when populations are low, then the insecticide phosalone can be used to control the codling moth. This insecticide is pretty gentle on aphid parasites and predatory mites that are then relied upon to control other mites and aphids in the orchard. This is a good example of IPM.

The NAS study of the Ferrari farm was completed in 1986. Since that time, the manufacturer of phosalone has decided to drop its registration. The market was too small, and the potential costs of reregistering the product were too great. The product is no longer available for sale in the United States.

The walnut IPM program described by the NAS is currently in disarray. There are two major alternative insecticides. Chlorpyrifos damages walnuts and, as a result, has not been a good insecticide for walnut growers to use. The major alternative is azinphos-methyl, which is a broad spectrum insecticide that will kill all the beneficial insects and parasites, and thereby totally disrupt the IPM program described by NAS. This IPM program is not sustainable due to the loss of a pesticide.

Summary

There are five major themes to this critique of the National Research Council (NRC) report on *Alternative Agriculture* and of the coverage of the issue of alternative agriculture.

First, the NRC case studies are data deficient. Information is often not presented for such key factors as: how often do these alternative farmers simply abandon fields because they are too weedy? How much pesticide use is there on these farms? The report hints at these questions, but does not provide any real quantified answers.

Second, the case studies are three years old. These case studies were completed for the 1986 crop year. The report came out in 1989. The farms are referred to as if they are currently sustaining their successes from 1986. One of these farms has gone out of business. At least two others have had to abandon key parts of their successful programs because of the emergence of a new pest in Florida and the withdrawal of a key pesticide in California.

Third, the Executive Summary is one-sided. The Executive Summary emphasizes that these farms have reduced pesticide use. There is no discussion of the invaluable role that pesticides still perform for these very same farms.

Fourth, the media coverage of the NRC report has been misleading. *The New York Times* front page article on the report starts off by saying that the NRC "has found that farmers who apply little or no chemicals to crops are usually as productive as those who use pesticides." I read the report quite differently. Most of the farmers studied by the NRC use pesticides and, in some cases, are among the heaviest users of pesticides in the country. This is not a report on organic agriculture.

Fifth, and finally, there is great potential that a series of uncoordinated rushed policy decisions with regard to pesticides could produce negative consequences for farmers and the environment. There are a great many policy initiatives with regard to pesticides—groundwater protection, food safety, farm worker safety, changes in the Farm Bill, and more research into alternatives. These are totally uncoordinated policies with great potential of running at cross purposes to one another. For example, the increased costs of the pesticide reregistration process has already caused a manufacturer to withdraw a pesticide that was a key component of the walnut Integrated Pest Management (IPM) program described in the NRC report. Hundreds of products are being dropped right now. The sentiment seems to be the fewer pesticides, the better. I do not think that there is a good perspective on the value of most of these chemicals.

The NRC report on *Alternative Agriculture* addresses this particular policy issue squarely. On page 218, the report recommends that as pesticides are regulated, it may be necessary to maintain some uses of more hazardous compounds, particularly in regard to their role in IPM programs. I think that is a suggestion that warrants serious consideration. That suggestion, however, has gotten almost no attention from the media.

Even with all of my criticism of the NRC report, I think that it makes an important contribution to the debate over pesticides. The report raises relevant issues regarding the debate. Perhaps my expectation was that it would provide answers to most of these questions as well. It doesn't. It probably should be viewed as an important first try to get on top of this issue, and not as the final word. As I mentioned at the outset, the National Academy of Sciences undertook a monumental job. The fact that they crammed as much detail as they did into their 448 pages has produced a valuable contribution to this debate.

Comments on *Alternative Agriculture*, A Report Prepared by the National Research Council

John F. Marten
Staff Economist, *Farm Journal*
West Lafayette, Indiana

SUMMARY

Alternative Agriculture contains a propaganda and blatant advocacy tone—replacing the scientific method. It asserts that "low-input farmers . . . produce more-at significantly lower costs"; yet can "identify no . . . studies that compare . . . conventional . . . with . . . alternative systems." (page 196) So it's "scientific pollution"!

Ten other errors, omissions, etc. include: (1) a "reduce purchased inputs" bias; (2) absent soil erosion impact study; (3) sustainable food supply ignorance; (4) farm program errors dominate; so, (5) distorted farm policy analysis drives conclusions; (6) farm income impact studies weren't reported; (7) aggregate issues—organic premiums, manure supply, etc. were ignored; (8) a fertilizer nitrate leaching bias; (9) "out of date" technology ideas; and (10) inaccurate, anecdotal case "research" studies.

Science took a beating from NRC. Nostalgic notions that rotations, tillage, manure, livestock, and small farms will sustain a growing world don't match facts. Authors favor "going back"—think less can produce more. It's "safer" inputs we need—not "less"! Whither science?

REVIEW

Alternative Agriculture has certainly drawn attention to organic agriculture, food safety, farm policy, and "science"—but perhaps in the opposite light deemed likely by its National Research Council (NRC) publishers. Rather than a new "sun" for scientists to orbit around in their search for truth, it might better be described as a "shooting star"—or a "meteorite" if we're kind and gentle. Clearly an environment of advocacy pervaded the 417 pages of *Alternative Agriculture* with the scientific method beating a retreat.

The report boldly asserts that "most low-input farmers produce just as much as their neighbors. . . . In fact they often produce more—at significantly lower costs." Yet on page 196, *Alternative Agriculture* authors can "identify no . . . studies that compare . . . costs and benefits of conventional agriculture with successful alternative systems." Which do they mean?

A dictionary definition of the word "propaganda" comes very close to capturing the writing tone of *Alternative Agriculture*; namely "the public spreading of ideas, information, or rumor for the purpose of helping or injuring an institution or person;" and also "ideas, facts, or allegations spread deliberately to further one's cause or damage an opposing cause." A careful study of the *Alternative Agriculture* text leaves the impression that a strong advocacy position is present and that the propaganda effect produced was (absent was a serious effort at science) likely an intended result.

Public perception of *Alternative Agriculture* was as follows:

> "The study (*Alternative Agriculture*) by the nation's pre-eminent body of scientists is perhaps the most important confirmation of the success of agricultural practices that use biological interactions instead of chemicals." (*The New York Times*, September 9, 1989.)

And then later that month, the following editorial in perhaps the most prestigious New Jersey daily newspaper:

> "The National Academy of Sciences has conducted an extensive survey on the value of pesticides. Its findings: Farmers who apply little or no chemicals to crops are usually as productive as those who use pesticides and synthetic fertilizers.
>
> "The study was based on comparing the productivity of so-called alternative farms that use little or no chemicals with the larger number of farms that make extensive use of pesticides and other chemical products. The academy found that well-managed alternative farms do about as well, and in some instances show greater crop yields and higher livestock production.
>
> "Wider adoption of proven alternative systems would not only improve the environment but should provide greater economic benefits to farmers, the report concludes.
>
> "This is the most devastating finding yet in the long debate over pesticides. The harmful health aspects of their use have been proved beyond debate. If there are no benefits to American agriculture in pesticides, then there is no reason for their presence.
>
> "The report deserves careful study by the U.S. Department of Agriculture and by Congress. It suggests fundamental policy shifts that truly would improve the world's food production process." (The Newark, New Jersey *Star Ledger*, September 27, 1989.)

These two short *Alternative Agriculture* summations by the urban press leave little doubt as to what information was provided by the committee and NRC staff in the executive summary, press releases, interviews, etc. Oddly, the NRC never conducted any survey (let alone an "extensive" one) and no study of "alternative" versus modern commercial farming systems was included. The book is just 417 pages of rambling, often repetitive notions, observations, and opinions. It never purports to use or apply the scientific method as shall now be illustrated with ten examples.

Some Errors and Omissions of Interest

While not meant as a complete or exhaustive list, the following ten samples of bias, errors, "confusion," etc. will serve to highlight the actual agenda of *Alternative Agriculture*.

1. **A "reduce purchased inputs" bias** surfaces on page 3; and it soon becomes a "principle" of good farming to "reduce" pesticide and fertilizer rates and use. This "cut chemicals and use crop rotations" theme is the central core of the text. At no time does the science concept of problem definition seem to interest the authors. They proceed to "the answer" as they see it—less input use from today's "high" rates. But the facts in Figures 1 and 2 show fertilizer and insecticide rates peaked long ago!

2. **No soil erosion impact study** is included. While repeatedly noting and urging that a rotary hoe and cultivator be used for three to six field operations to replace herbicides, the committee neglects the erosion and sustainability consequences (not to mention, lost timeliness, extra labor, and machinery needs). Over 25% of U.S. cropland (100+ million acres) has some erosion problem. Can we just scratch no-till? With safe chemical suppressants, isn't it a good tillage choice? Shouldn't we carefully weigh chemical versus soil loss tradeoffs? I would think so. Many 1995 farming plans will require it!

3. **Food demand ignorance prevails** in discussion throughout the text—and so drives the set of alternatives to modern farming that are deemed "better" by this NRC effort. At no time is the focus on how to sustain (feed) six billion folks before the year 2000, eight billion by 2020, etc., with more safe, efficient, soil conserving "artificial" inputs. Rather these 17 scientists spend their major efforts looking back to the 1940s and 1950s era when "no chemicals" was often the norm with a population of under three billion people; 60 bushel corn yields, and five million farms. Those who were farm-born and reared may recall operating a scoop, a hoe, and a pitchfork then—not aerial sprayers, high-tech livestock environment systems and computers. At least 25% of the text should have focused on what the 2000s will bring: more people; needing more food; requiring higher yields; meaning more purchased inputs; given a fixed land area. Bio-tech, better input/output ratios, safer inputs, less (tillage) erosion, etc., fit the problems at hand.

4. **Farm program errors were "normal"** in the text. Some examples:

   A. The repeated claim (pages 10, 235, etc.) that "70% of the nation's cropland" is enrolled in ASCS programs is wrong—the 40 to 50% range is accurate.
   B. On page 10, the authors say Agricultural Stablization and

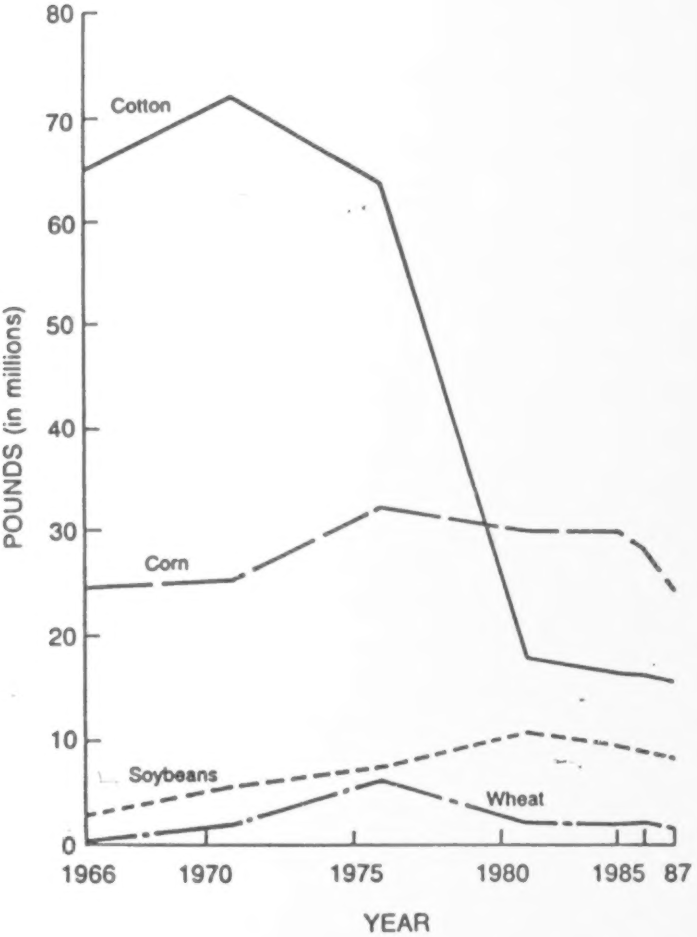


Figure 1. **Insecticide use estimates on corn, cotton, soybeans, and wheat (*Alternative Agriculture*, © 1989, by the National Academy of Sciences, National Academy Press, Washington, D.C.).**

Conservation Service (ASCS) rules "penalize [penalizing] those who . . . reduce pesticide applications." This is false. No such rule applies and since all payment yields were frozen in 1985, no penalty occurs.

C. Pages 10, 11, and 237 assert "farmers wishing to rotate must generally forfeit payment(s)." Not quite. Every ASCS office via Handbook 5-PA SCOAP allows election of a "pattern designation" for rotated base crops. Most practical farmers know this.

D. The most amusing factual error regarding ASCS rules is that rye is a program crop—thus isn't free to be used as a cover crop, nitrogen enhancer, etc., in rotations. It is not a program crop—and hasn't been

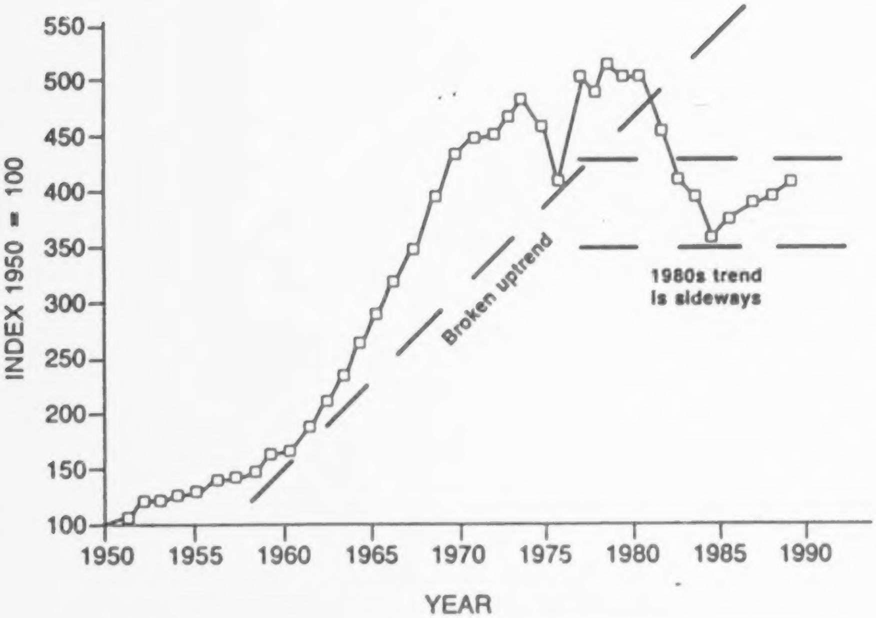


Figure 2. Fertilizer use/acre peaked in 1978 (U.S. Department of Agriculture Index of Input Use, 1989).

in modern times! Any farmer is free to plant rye, any time, any amount, on any farm!

E. Finally, the authors allow (page 235) that farmers "enroll in federal programs" for income support for soybeans. Sorry—but beans have no target price, no "program," no signup, etc.

Summary: If just one of these 17 "scientist" authors of the NRC report had required effective reviews, or been a real farmer, or visited an ASCS office—major errors could have been corrected.

Fortunately, the General Accounting Office (GAO) did survey growers to see if this "blame the farm program for forcing farmers to use more chemicals and establish higher ASCS yields" notion was accurate. No, said farmers! This 1990 research by GAO did find five real barriers to farmer adoption of alternative agriculture practices. Farmers ranked the following as fairly strong concerns: (1) greater management is required; (2) yields may decline; (3) weeds may increase; (4) profits may decline; and (5) farm labor is unavailable. Why didn't the NRC do such a survey?

5. **Distorted farm policy analysis** resulted from the errors noted above. As both Figure 2 and Table 1 illustrate, fertilizer rates haven't escalated with rising target prices over the last 15 years. Yet this is the core assertion that drives the *Alternative Agriculture* farm policy analysis and needed changes that they suggest to Congress.

Table 1. Target prices don't drive fertilizer rates

Year	Lb. N/A*	Target price $/bu.	N-to-target correlation	Lb. N/A*	Target price ¢/lb.	N-to-target correlation
1976	127	1.57	N.A.	81	43.2	N.A.
1977	128	2.00	+	78	47.8	–
1978	126	2.10	–	76	52.0	–
1979	135	2.20	+	71	57.7	–
1980	130	2.35	–	72	58.4	+
1981	137	2.40	+	72	70.9	–
1982	135	2.70	–	82	71.0	+
1983	137	2.86	+	81	76.0	–
1984	138	3.03	+	81	81.0	0
1985	140	3.03	+	80	81.0	–
1986	132	3.03	–	77	81.0	–
1987	132	3.03	0	82	79.4	–
1988	137	2.93	–	78	75.9	+
Change in 13 years	+7.8%	+86.6%	6+/5–	–3.7%	+75.7%	3+/8–

* Nitrogen/acre; all U.S. Department of Agriculture data from *Agricultural Outlook*, May, 1989.

The NRC report text (pages 11, 17, and 205) asserts that a farmer's "principal objective" is to "maximize yields on base acres. . ., thus maximizing deficiency payments." This is false in both theory (see the hypothetical Figure 1-30, page 71 in *Alternative Agriculture*) and practice—as Table 1 data show. The ASCS yields are frozen—so getting a high 1987 or 1990 yield has no effect on payments. That's a fact. So the theory (as the GAO found) is absurd! Next, a "real world" test.

Table 1 shows the highest input nutrient (nitrogen [N]) on the two highest input-major crops. A plus sign (+) by a year means the N rate moved with the target price—a minus sign (-) means the opposite. Summing the two crops; N "followed" nine times and went the opposite way 13 times. And while targets zoomed 75 to 90%, the N rate change was -4 to +8%. Case closed!

Conclusion: The most basic premise driving the *Alternative Agriculture* policy model is false. Any tabular or simple listing of nitrogen-phosphorus-potassium (NPK) data would have shown this. Why didn't the text contain the data? Did all 17 NRC committee scientists just assume greedy farmers and stupid policy insured their outcome? One glance shows the opposite.

6. **Farm income inpacts were omitted** at several key junctures. The Nebraska study outlined in Table 2 was a long-term, well-documented project by Glenn Helmers, a member of the *Alternative Agriculture* committee. These data drew only a short paragraph on page 233 of the *Alternative Agriculture* report noting: "Different fertilization regimes, including manure only, were found to have little impact on yields and profitability." Is this right?

Table 2. Nebraska's low-input rotations produce low yields and low incomes[a]

Item	Crop rotations				
	C-Sb (1)	GS-Sb (2)	C-Sb-C-O (3)	C-Sb-C-O (4)	C-Sb-C-O (5)
1. Herbicide	Yes	Yes	Yes	No	No
2. Insecticide	Yes	Yes	No	No	No
3. NPK source	Fertilizer	Fertilizer	Fertilizer	Fertilizer	Manure
4. 8-year average yields					
Corn/grain sorghum	95.6	85.0	87.9	83.5	81.6
Soybeans	38.0	42.6	36.0	35.9	32.4
Oats	—	—	53.4	51.7	56.2
5. 10-year average yields					
Corn/grain sorghum	108.7	88.3	90.5	86.6	84.4
Soybeans	38.0	41.4	37.1	37.0	33.9
Oats	—	—	60.4	60.3	64.6
6. Average net return/A[b] (1978–1985)	$175	$172	$112	$115	$104
7. Return to management on 600 A if fixed costs = $125/A	+$30,000	+$28,200	-$7,800	-$6,000	-$12,600

[a] C=corn, Sb=soybeans, GS=grain sorghum, O=oats/sweet clover. Yields from 1978 to 1985/1987. Site is Mead, Nebraska. Oats straw, 100 bales/A market value.

[b] Average prices: corn $2.50, soybeans $6.11, grain sorghum $2.19, and oats $1.41, CPI-adjusted (1985 base). No government payments. Manure cost 50% of NPK fertilizer; 8.5 tons on corn, 6 tons on oats. Calculations from Glenn A. Helmers, *et al.*, Department of Agricultural Economics, University of Nebraska-Lincoln; line 7 by the author.

This is an odd summary since the ten-year (item 5) corn yield change is 24 bushels per acre—that's a 29% gain! And notice (item 6) that the economic advantage is $71 for C-Sb over rotation 5 (manure)—a 68% profit boost! The *Alternative Agriculture* text calls these "little impacts." And note all economic calculations shown are for the eight-year results when corn only gained 14 bushels per acre—the income divergence would widen at the higher 24 bushels per acre difference.

Iowa State University also has similar results from a 12-year study (Michael Duffy, Associate Professor, Extension Economist). The corn yield differential is 137 bushels (C-Sb) versus 75 bushels (C-O-M) with 20 tons of manure. Economic returns are 54% higher at $116 versus $75 per acre for the modern plan. Years of work—same result!

Summary: With Glenn Helmers on the NRC committee and John Pesek (Iowa State University, Department of Agronomy) as the chairman, how did these two good research efforts miss the cut? Either set of data fully disproves the "yields and returns are the same or higher" notion. It takes 15 years to replicate and collect these results—argument enough for sifting them for clues—and printing them in this lengthy text.

7. **Macro or aggregate issues ignored** include some express; other implied; like:

   A. "Reduced use of these inputs (fertilizer and pesticides) lowers production costs." Not in the two cases described above—costs per bushel increased in both the Iowa and Nebraska studies—that's why net/acre fell! (Price is fixed for both.) And this notion also fails when (if) all U.S. farms begin to cut input levels. Reason: input prices fall as demand slips; crop price rises only slightly; so the high yield advantage expands! Less never makes more!

   B. The "manure supply and cost" problem is never outlined, or even mentioned. The United States produces under 20% of its NPK needs as manure—and in the wrong places. The 12 cornbelt states have only about 10% of needs given current livestock numbers—which "environ-experts" claim are way above need. So what would happen if the *Alternative Agriculture* report's "rotate and use manure" caught on? Clearly, manure prices would escalate wildly as demand in Iowa drew 12 bidders for each spreader full! So farmers would just bid away profits into higher manure and land costs.

   C. The "production cuts mean prosperity" notion bubbles up routinely in *Alternative Agriculture*. The (false) logic is: all use less inputs; so production drops 25%; thus prices almost double (\$4 corn and \$9 beans); and so farm income rises with the "manure" method! Wrong, once the real world is added. Why? All U.S. farmers don't change to low yield farming. Manure, labor, land, and machine costs rise. Overseas crop production explodes! Prices are less than 20% higher after two years.

   Summary: All attempts to "idle our way to prosperity" will fail. Inefficiency is not the solution!

   D. The "organic means big price premiums" argument still lives in *Alternative Agriculture*. But not in real life—at least for long. Reasons: the "niche" isn't deep or wide—makes the market easy to flood. And given the fixed size of the human stomach—price is very inelastic on "organo-deli" food items. So current efforts to define and legislate an "organic label" will produce the exact opposite results intended. Margins will collapse and output shift mainly to huge farms! Organic "sounds too good to be true"—it is!

8. **A fertilizer nitrate leaching bias** shows up repeatedly in the text. One wonders how—short of "isotope tags"—the authors figure it is usually "artificial" or "inorganic" N that's getting into groundwater? Maybe they had data not presented in the 417 pages? There are data from Michigan that show 50 to 60 parts per million (ppm) of nitrate at the five-foot level under growing corn with manure or alfalfa plowdown—versus only 10 ppm for standard N fertilizer rates.

   A similar Minnesota study showed hog manure nitrate levels at 41 ppm versus 12 ppm for anhydrous ammonia at the five-foot level after one year passed. So it is entirely possible that with 16% of all cropland in hay, and livestock manure near 20% of fertilizer N use, that over 50% of groundwater nitrates are organic not fertilizer based! Not the idea you get reading *Alternative Agriculture*!

   Finally, between pages 208 and 209, a four-color U.S. map of nitrate levels in mg/liter is presented—courtesy of the U.S. Geological Survey. With four years to study, and 17 pairs of eyes, how could the explosive situation in southeastern Pennsylvania be missed? It's the largest 3+ mg/liter zone in the United States—covers 20% of the state! What kind of farming predominates in southeastern Pennsylvania: one wonders? Small crop, livestock, manure, rotation, family farms. From Lancaster to Kutztown, that's all you see. Lots of plow-down alfalfa, manure, and crop residue—and high testing "N in water" results.

Summary: Low input systems which use legumes and manure over fertilizer N may: (1) force manure application at the "wrong" time; (2) boost soil compaction accordingly; (3) cause application errors as a result of N content variability; thus, (4) yield a less controlled, much higher nitrate loss risk situation.

9. **An "out of touch" problem** occurs constantly in the text. Scouting for pests is seen as new or "alternative" when it is an early 1970s concept. It shows up clearly in Figure 1, falling insecticide rates since 1976 (14 years) are one outcome. Farmers apply corn insect control to less than 50% as many Illinois corn acres now as compared to 1975.

   And integrated pest management (IPM), one needs to recall, is not an alternative (atypical) new way to husband crops—but at least a 20-year-old concept. Over 80% of U.S. cotton is now grown with IPM systems.

   Finally, the notion of ridge tillage is hardly avant-garde! Rather, the initial ridging planter (Buffalo) just celebrated its birthday—number 30! That's three decades old machinery—so the idea was from the 1950s.

10. **Questionable anecdotal research** is a kind way to sum up the 11 so-called "case studies" in *Alternative Agriculture* used to show "the range of successful alternative systems available." Essentially none of the 11 cases stood up under scrutiny and recontact during late 1989. An Iowa farmer wrote me an angry note that his wife who "teaches" in *Alternative Agriculture* (1989) only taught one year (1986) and his "case study" was just one interview four years ago! A Virginia farmer acknowledges that his "bale Johnson grass with the soybeans" program farm has been out of business (subdivided) for three years!

    Five of the 11 cases are organo-premium situations—three losing money now on beef, rice, etc.—and none sustainable long-term. And a Kutztown, Pennsylvania farm—mostly Robert Rodale Institute land—is termed "less profitable than a comparable conventional farm" even in the *Alternative Agriculture* text! So why term it "successful"?

    Summary: Allocating 170 full pages to 11 "case studies," while giving only one paragraph to replicated (10 to 12 years) Iowa and Nebraska—real research—is beyond science and its methods! Did the authors not expect readers to find that over 100 pounds of fumigant replaced the pound-or-so of insecticide dropped in one IPM case? The cases weren't "studied" (I have confirmed); nor can most be described as successful; and, one doesn't even exist: GOSH—is this science?

So who needs a horse? The parts of *Alternative Agriculture* that match modern farm methods are good review. But the tone and scientific approach are biased; most *Alternative Agriculture* conclusions are not backed by facts. Fanatical notions that rotations, manure, livestock, and small farms will match current production and economic results don't fit the facts. The 17 scientists who approved this book took a detour: our car was putting out too much smoke, so they got us a horse! There is another (more scientific) way—fix the car and get cleaner fuel!

Alternative Agriculture Policy Might Induce Rapid Adoption

Arnold Paulsen
Professor of Agriculture and Economics,
Iowa State University

SUMMARY

Many of the high management, low waste practices described in *Alternative Agriculture* are not sufficiently economically attractive to be adopted. Appropriate incentives could be created by associating the negative value that society places on pollution or resource depletion with specific farming practices. To avoid the charge, farmers would adopt the practice if it paid or if it compensated society. Possible incentive mechanisms are outlined to reduce nitrate pollution in Iowa.

REVIEW

Alternative Agriculture is technically defensible, attractively illustrated, and well written. Findings, conclusions, and recommendations from the 20-page executive summary have been widely reported, but subsequent discussion seems to have generated more condemnation than praise for the report and its authors. Negative reactions and attacks on the report and its authors, I believe were predictable, and due more to long-standing preferences or self-interest in not discussing these problems than to any new technical information or policy issues raised in the report. The report is a prestigious messenger, but only one of many about neglected problems. I especially favor attention to these: (1) federal policies that work against benign agricultural practices, (2) lack of research about aggregate consequences or on-farm integration of alternative agricultures, and (3) nitrate and pesticides from farming that are major water pollutants. The report has put pollution from conventional farming practices on the national policy agenda. The messenger should not be discredited.

Although entitled *Alternative Agriculture*, the report by the National Research Council predominately considers movements toward high management/low waste agriculture. I want to consider one example important to Iowa.

Nitrates are a significant water pollutant. Much of the current nitrate pollution from agriculture probably could be eliminated by: (1) carefully incorporating manure from animals in confinement into cropland, and (2) applying only as much nitrogen as the corn can use. There are no really difficult technical problems associated with adopting these practices. Wider adoption has great potential for nitrate pollution reduction all over the country. However, the reward to farmers for hauling manure or avoiding excess nitrogen is apparently too small. Several of the case studies reported successful integration of livestock and crop rotations. However, fewer and fewer Iowa farms integrate livestock and sod-based rotations. I believe most of the practices of *Alternative Agriculture* are technically feasible, reduce negative externalties, are partially adopted but economic incentives are weak.

Anhydrous ammonia from natural gas is the preferred nitrogen fertilizer for corn in Iowa. It costs about $0.11 per pound. It is very cheap, widely available, and easy to apply mechanically. The season is occasionally favorable enough for a full crop of 180 bushels, but only about one year out of five. In other years, there is usually more nitrogen in most fields than the plant really needs, but the yield is not depressed. As a result, the most secure and highest profit strategy is to over apply nitrogen. This makes sure there is enough nitrogen in case the season is favorable. Over application of nitrogen may occur in four years out of five, but that is cheap insurance to assure the maximum yield every year.

A farmer could probably save about $10 per acre four years out of five by testing leaf tissue periodically and carefully feeding the plant only what it could use. If done right, the yield of corn would be as high as with over application. Water pollution would be less. Natural gas to make the ammonia could be saved. The City of Des Moines would be healthier or need to spend less to remove the nitrates. But the practice of calibrated feeding of nitrogen is not appealing. It required extra effort, equipment, and skill, plus additional trips over the field. There is some risk of miscalculating—one could under apply and miss some potential yield. A loss of ten bushels would pay for an extra 90 pounds of anhydrous ammonia. Extra nitrogen seems cheaper and safer than tissue analysis, calculation, and extra trips.

Public policy could create incentives to reconsider this practice. *Alternative Agriculture* indicts federal policy for working against benign practices. The report does not suggest public actions to create incentive. I believe the potential impact of policy to create appropriate incentives is much greater than any deterring impact of current federal policy.

To create incentives, policy should associate the negative value society puts on environmental damage with the farming practices causing the damage. For example, the charge for over application of nitrogen would be at least the cost in Des Moines and other places to endure or remove nitrate pollution. If over application were continued under such a policy, society would be compensated. If the over application is avoided, society would be assured the costs to avoid it would be less than the value of the damage avoided. Society would be better off with such a policy.

The policy could be implemented by a program to collect a deposit on all pounds of nitrogen purchased above the minimum expected requirement. For example, a deposit of $0.50 per pound could be collected on all purchases above 80 pounds or whatever is the requirement for average yield in a sod-based rotation. As much nitrogen as desired could be purchased. The deposit would only ensure payment of damage for any over application. At the end of the year, yield could be observed, nitrogen consumed and calculated, and a refund made.

Policy might also create incentive to recycle the nutrients in manure. This policy would be implemented by a program to collect a waste disposal deposit as a condition for a permit to operate livestock confinement facilities. The deposit would be per cow, pig, or chicken and reflect the perceived potential social cost from environmental damage caused by pollution from waste. The refund would depend on the particular livestock waste utilization method actually used. Producers of livestock would be free to handle the waste in whatever manner desired, but the refund from the deposit would vary according to the environmental damage from the method employed. Presumably, the charge would be highest for the most polluting method of waste handling with the least charge for completely recycled nutrients. Careful storage and application to cropland at useable rates might completely avoid charges. After implementation of the policy, if pollution were continued in some cases, society would have been compensated. If nutrients were recycled, the cost incurred would be less than the value of damage avoided. Society would be better off.

To the extent costs of raising livestock were increased as a result of an incentive policy, these would be expected to be passed forward in higher prices to consumers for livestock products. After adjustment to the policy, farm product prices would reflect the full cost of production including waste disposal or environmental damage.

Literature Cited

Tietenberg, Tom. 1988. *Environmental and Natural Resource Economics*, Scott Foresman, Glenview, IL.

U. S. Department of Agriculture, Economic Research Service. 1985. *Natural Resource Issues and Policy*.

Book Review:
Alternative Agriculture

Clinton B. Reeder, Ph.D.
Commercial Grain Farmer
Pendleton, Oregon
Former Professor of the Department of Agricultural and Resource Economics
Oregon State University, Corvallis

SUMMARY

We should not ignore the caution flags the book waves, nor should we forget that U.S. agriculture has been progressively responding to both economic and environmental concerns for generations, searching for

"sustainable alternatives."

Cropping alternatives and rotations are often not economically feasible in all agronomic zones, especially not if a large number of farmers grow a particular minor crop.

Repeated fertilizer tests on my farm, designed specifically to find ways to reduce fertilizer expenditure, have actually led me to increase fertilizer use as I refine application procedures and timing, rather than reduce it as the book suggests.

The book would be much more helpful if it explicitly recognized the significant differences among various soils and hydrologic conditions among various agronomic zones.

Because much of the book will not stand up under close scientific scrutiny, especially not under good economic analysis, any public policy based on its contents should be established with significant capacity for permitting timely midseason adjustments to unforseen, often unresearched consequences of modified farming systems.

REVIEW

The *Alternative Agriculture* book is sometimes referred to as the "bible" for LISA (Low Input Sustainable Agriculture) advocates. On the other hand, others refer to the book as the handbook for returning U.S. rural areas to the days of Low Income Subsistence Agriculture. As a full time commercial farmer, I have found it rather easy to develop a "love-hate" attitude toward the book.

My overall impression of the book is that the authors were working from a predrawn conclusion that the LISA concepts were not only practicable, but that if they searched the nation thoroughly enough for evidence to support that conclusion, they could prove their conclusion to be correct. Hence, the book is very naively biased toward *Alternative Agriculture* as being not only feasible, but practicable for universal adoption by modern agriculture.

Having searched diligently, the authors have indeed provided some very intriguing insights to various production possibilities. It is obvious from the content of the book that in some agronomic zones (geographic areas with certain weather, soils, rainfall timing and amounts, growing season length, and temperature patterns, etc.) there are cropping patterns that may well be superior to the norm—at least usable by a much larger number of persons than now use them.

The major flaws in the book are what it fails to include, and the "universal inferences" from a limited database, implying that what might work in one agronomic zone will work in all agronomic zones, what works on one farm will work on all farms—a very questionable inference.

Transition Costs, Procedures, and "Surprises"

The book, while providing some potentially useful insights, does not however, generally provide meaningful information that would help transition from current practices to those alternative cropping patterns, nor does the book provide any of the mass of research data that shows the tremendous risks, costs, and economic impracticality of some of the alternatives.

In my own case, for illustration, I have spent the past eight years moving my farm from a moldboard plowing system to a chisel-disk higher residue system. It has worked far better than expected as far as erosion control and earlier seeding is concerned.

However, the very significant incidence of plant disease accumulation in the increased surface residue almost created an unexpected financial disaster for me in the 1989 crop. The spring weather stayed wet and cool longer than normal, and a major fungus disease erupted in my wheat in epidemic proportions.

In only two weeks, my fields changed from some of the best looking wheat in the county to some of the worst, with about one-third of the flag leaf lost over much of the crop. The epidemic was stopped, fortunately, by the onset of hot, dry weather.

Otherwise, it would have cost me another $15 an acre for chemicals plus application costs of about $4 per acre to hire a plane to fly on the chemicals—to maybe have stopped the disease. Effective controls for this particular disease are not yet well developed.

Cool nights plus heavy dew have brought on the same problem for the 1990 crop. Since the only reliable controls for the disease are burning the crop residue and/or moldboard plowing, we are returning to use of the plow on at least half the land for the 1991 crop. Because of the potential high crop loss and/or the high cost of chemicals to treat the disease, we cannot afford the risk of 100% high-residue seedbed under our growing conditions.

Crop Rotations

The *Alternative Agriculture* book suggests I consider some kind of crop rotation to take care of the disease problem. If there were an economically feasible rotation, I and most of my neighbors would have been using it a long time ago. We are constantly looking for alternatives to diversify our farms.

My farm is in an area with about 15 to 17 inches annual rainfall. There are other crops we can grow, but few will yield as well in our agronomic zone as wheat or barley. Barley in our rotation helps with wheat disease problems, but since it is grown basically under the same cycle of operations as the wheat, the benefits are limited.

My field tests in 1989 indicate that using barley in a rotation likely has a longer term benefit to wheat yields. However, in my tests, the benefit is only 1.35 bushels per acre. It is definitely not economical for me to use barley in rotation with wheat, unless I cannot grow wheat for some reason.

Rotation Concept

We are moving to use of the "rotation concept," but will use rotation of tillage practices rather than rotation of crops. One of the major purposes of rotation is to break the life cycle for disease, which we think we can achieve, at least in large part, by cycling a reasonable variety of tillage practices over a number of growing seasons.

I think this may be one of the productive ways to use the book, to look for "concepts" rather than specific ideas, and then adapt the concept to particular growing conditions.

Markets

The primary problem with alternative crops and rotations is markets, which the book seems to overlook completely—a "Fallacy of Composition," assuming that if a practice will work on one farm, it will therefore work on most farms.

There are many sad cases across the nation where farmers and investors have assumed "if I can grow it, I can sell it," only to find that many markets are well established contract markets. Most markets, contract or otherwise, are very difficult to enter with any significant scale of new production.

Without a contract, growers often cannot sell what they grow, except in some more freely accessible fresh produce markets or from roadside stands, all of which are highly competitive and require some significant expertise in merchandising to make them profitable ventures.

If a new producer tries to enter the market by "buying in" through lower prices, established market participants will match the lower price to keep their markets. Buyers wanting to maintain established supplier relationships they have come to trust do not just jump willy-nilly from one supplier to another. The new entrant, often having limited financing for such a contest, often goes broke in a short time because of the significant cost to enter a market.

If grain producers in my home state, Oregon, were to shift 10% of their wheat acres to fruits and vegetables, wheat farmers would about double the acres of these alternative crops in Oregon, which is a major producer of such crops. The markets for the alternative crops simply would collapse, with even a much smaller increase in acreage, with the effect rippling through markets far outside the borders of Oregon. The same can be said for hay crops and other crops with annual production acres relatively small compared to the average annual acres of the basic grain crops.

If market prices fall because of the increased production of an alternative crop, then the economic feasibility of the alternative is that much worse. Without viable markets, the alternate crop then becomes basically a nonmarketable "cover crop," which significantly uses up moisture without generating any net income to the farm. Since moisture is the primary limiting factor, the only major contribution the alternative crop makes is to soil tilth.

No research data currently available to me demonstrates that cover crops are generally economically feasible, either in the short run or the long run, in nonirrigated areas with rainfall less than 20 inches. The positive impact on soil tilth and subsequent crop yields is not sufficient to warrant developing a cropping cycle that includes cover crops on most soils in such agronomic zones.

Fertilizer Dependence

The *Alternative Agriculture* book suggests farmers could reduce their use of commercial fertilizer without loss of yield. That is likely a gross misrepresentation of the truth for the nation as a whole, except maybe in some parts of the country where rainfall is high and the cropping alternatives numerous, or possibly on some irrigated ground. However, to assume farmers as a whole could reduce fertilizer application by very much is to also assume farmers do not watch the economics of fertilizer application.

Fertilizer application is a major farm expense, and unless there is a good reason to overapply fertilizer, it is not generally going to be done for any period of time, especially not in lower rainfall areas.

Excess nitrogen application in areas with more limited rainfall has very severe negative consequences. The crop can shrivel severely when moisture is inadequate for the nitrogen applied, generating kernels that have low test weight; that are blown out the back of a combine and lost in large quantity; that are downgraded by the market, and have sometimes too high a protein level for optimum marketing. The negative financial consequences of overapplying fertilizer can be very substantial. Hence, most farmers, especially in nonirrigated lower rainfall areas watch their application rates very carefully.

Split Fertilizer Applications

It is also suggested farmers might want to split-apply their fertilizer, part in the fall and part in the spring, in order to reduce the likelihood of leaching down into groundwater. In some cases, in areas particularly vulnerable to leaching, split-application may be particularly appropriate.

In my own circumstances, I also find split-application to be appropriate, but not for groundwater protection purposes. It simply gives the crop a much needed boost for early spring growth, which is critical to yields. If I apply 80 to 85 pounds of nitrogen in the fall, followed by 30 pounds in the spring, I can get a 12 to 15 bushel per acre yield increase over only applying 90 to 100 pounds in the fall with no spring application.

However, if I apply 55 pounds of nitrogen in the fall, and then 30 pounds in the spring, the yield increase is only four bushels per acre compared to no spring application. Of critical concern, however, is that the lighter fall application does not lead to as strong a plant coming out of the winter and the plants do not tiller as well. Hence there are fewer heads and the total yield is much lower than with the higher fall application.

The economic benefits to me of maintaining the higher fall application plus a spring application is generally between $10 and $15 per acre, as compared to reducing the fall application and the overall application by about 25% (the percent reduction implied by some of the LISA literature as being possible without any yield loss to U.S. farmers).

Another consideration that limits split fertilizer applications in low rainfall areas is the insufficient rainfall later in the spring to take later fertilizer applications down into the root zone. Using shanks to directly inject the later applications tears up plant roots, exposing them to root diseases and reducing their capacity for moisture uptake. It also causes significant additional loss of moisture by evaporation up through the shank marks, making such applications very uneconomical. Hence, in drier areas split-applications must usually be made in later winter, prior to knowing how much soil moisture will be available later in the spring.

The optimum fertilizer rate on my farm does not change much over a wide price range for the fertilizer, nor does the optimum application rate change significantly over a wide range of prices for the crop. This is substantiated by ten years of yield and application rate tests, plus annual soil tests, and includes years of both above average and below average rainfall. I have conducted repeated on-farm tests specifically designed to reduce fertilizer expenditure, if at all possible. I have found no way for me to economically justify reducing my fertilizer application rates—it is one of my most productive investments. In fact, my research has actually led me to increase fertilizer use rather than reduce use, as I refine application procedures and timing.

Groundwater Quality and Fertilizer

What about groundwater concerns? It takes about 3.5 inches of rainfall in my soils to move nitrogen down one foot deeper in the soil. With an average rainfall of about 15 to 17 inches, the deepest any of the nitrogen generally moves is 5 feet, which I verify with regular annual soil tests to 6 feet of depth. In a normal year, the nitrogen does not go much deeper than three or four feet. Wheat plants will root in excess of 6 feet deep, and feed on nutrients and moisture. In addition, as the soil dries, the nitrogen apparently moves back up as the soil moisture percolates up toward the drying surface.

When nitrogen application rates are balanced to available soil water, in generally nonvulnerable soils, the chance of nitrogen leaching to groundwater is very small.

The book would be much more helpful if it explicitly recognized the significant difference among various soils and hydrologic conditions in fields, pointing out that fertilizer application practices are not universally a problem, except in the more vulnerable hydrologic areas.

Faulty Inference Among Agronomic Zones

This brings me to the major flaw I find in the *Alternative Agriculture* book. It takes research from one agronomic zone, predominantly higher rainfall areas in the Midwest, and makes inference to U.S. farmland in general. That is, in my opinion, scientifically irresponsible.

Statistical inference rapidly becomes less reliable the more the area to which the inference is made deviates from the test area. Small differences in average temperature, rainfall timing or amount, natural soil chemistry, growing degree days, date of last killing frost, differences in weed populations, and incidence of various diseases dramatically affect the viability of any crop or cropping pattern or tillage practices.

On my farm, within a radius of less than five miles, rainfall varies considerably, from being adequate to raise cannery peas and wheat in annual cropping pattern to being inadequate enough that farmers use a summerfallow rotation, raising only one crop in two years so as to accumulate enough moisture to raise that one crop economically.

If there are such significant variations in agronomic zones within five miles of my farm, then it is very foolhardy to be making nationwide general "micro-management" inferences from a piece of research conducted someplace in Iowa.

Inadequate Economic Analysis

One redeeming factor about the book is that it does recognize its shortcomings in the economics and marketing arena (see pages 22 and 23 of the Executive Summary, and Chapter 4, page 195). The tragedy, however, is that in spite of recognizing this shortcoming, the book fails to link that shortcoming to the practicality of many of the alternatives indicated in the book.

Had the authors spent more time researching why farmers currently use their established practices, and why many farmers have tried and rejected many of the alternative agriculture options in the book, the authors would have provided meaningful insight into the conditions under which the suggested options might have feasible application. This would have made the book much more useful as a policy development tool.

Sustainability of Current Practices

The book makes a major error in not addressing the long history of research and testing that provides the basis for current practices. U.S. agriculture has been copied around the world for generations, and for good reason. Our methods have been time-tested and researched carefully, from one agronomic zone to another. We have had the world's best nationwide system for agricultural development, and it has served us and the world extremely well.

Like in any system experiencing ongoing development over a long time period, we have experienced some unforeseen adverse consequences over time from various agricultural practices. The book would have been much more productive had it placed the "alternative agriculture" ideas into appropriate historic context, as options necessary in those situations where the historically unforeseen consequences can no longer be permitted if we are to adequately respond to contemporary environmental concerns.

Agriculture has been progressively responding to both economic and environmental concerns for generations—"alternative agriculture" is absolutely not a new concept, just a new name for the ongoing pattern of development in U.S. and world agriculture, with an increased emphasis on environmental concerns.

Book Not an Adequate Basis for National Policy

Using the book as a basis for sweeping national policy decisions is at best a bad decision. It is not appropriately presented in proper historic context. Too much available good research showing the impracticality of some of the options suggested is not included in the book. There is too big a gap in the available research base concerning the consequences of major changes in cropping patterns. There is far too little meaningful reference to variation among the various agronomic zones in the United States and the implications thereof to crop production practices. The financial risk factor is noticeably missing from the book—a glaring shortcoming, with dramatic misleading consequences for policy decisions.

Recommendations

1. In my opinion, the book should be read, should in fact be studied—but very cautiously— for ideas and "possibilities," both in cultural practices and policy options, keeping in mind that farming is for the most part "husbanding sensitive ecological systems" that once disturbed, even in small ways, often take years to restabilize. During the restabilization process, there can be many very unexpected and often times costly "surprises." Hence, any policy that mandates changes in current farming systems should be established with significant capacity for permitting timely midseason adjustments to these unforeseen, often unresearched consequences in a manner that minimizes risks and adverse financial consequences for farmers and others in the economy dependent on the economics of agriculture.

2. I recommend the authors follow this book with another that very carefully investigates why farmers are using their current practices. The research team should look at both the more progressive farmers, and those less progressive, to understand the dynamics of change and risk management on the farm. Those of us on multiple generation farms have been doing something quite sustainable, or our farms would long ago have been lost to the family. The land does not permit abuse to continue very long without very negative economic consequences.

3. In addition, I recommend the authors publish a companion book that collects all the currently available papers, magazine articles, and other publications written in response to the *Alternative Agriculture* book. I think the insight gained from these materials would add significantly to the debate concerning sustainable alternatives for U.S. agriculture.

4. If this book is used in university classes, I recommend another book be used with it. The other book is: *Playing God in Yellowstone: The Destruction of America's First National Park*, by Alston Chase. It was published by Harcourt, Brace, and Jovanovich in 1987. This book also illustrates rather dramatically some of the problems associated with faulty inferences. Furthermore, the book makes rather evident some of the severe problems associated with trying to manage natural resources "politically" rather than on the basis of good, reliable science that "fits" the issues and the particular environment of concern.

   Neither book should be used as "fact." Both books could serve as delightful references, however, in teaching something about "critical thinking," "problems involved in the public management of natural resources," and "the appropriate role of science in the politics of natural resources."

5. I recommend, should another book be written, that the editorial staff include several "farming practitioners," persons who walk and work the land daily, who are familiar with the soil and growing conditions from several parts of the nation, and who represent a wide range of farming practices. They would lend significantly to such a book, offering insight of much greater value as policy guidelines, with good likelihood of general acceptance and appropriate adoption.

6. Finally, I caution public policy advocates to not lean on the book as "gospel." It will not in many ways stand up under close scientific scrutiny, especially not under good economic analysis. Most importantly, most of the ideas, even though technically feasible in some situations, are simply not directly transferable to all agronomic zones, except possibly to some extent in conceptual fashion.

Conclusion

Reliable scientific evidence does not support that agriculture is causing widespread significant major devastation to the environment, nor does it support that widespread groundwater contamination is occurring. It does indicate there are substantial "areas of concern" that we certainly need to address in the immediate future with modified practices.

However, we as a nation need to be very careful that we do not impose on our entire agricultural system "solutions" that are really only needed in certain vulnerable areas, and that if applied universally might well cause many more problems than they solve, quite possibly and unnecessarily causing U.S. agriculture as an industry to become much less competitive in the international markets.

Alternative Agriculture
Sustainability is not Enough

Vernon W. Ruttan
Regents Professor, Department of Agricultural and Applied Economics
and Department of Economics, and Adjunct Professor
Hubert H. Humphrey Institute of Public Affairs
University of Minnesota

SUMMARY

Traditional agricultural systems that have met the test of sustainability have not been able to respond adequately to modern rate of growth in demand for agricultural commodities. A meaningful definition of sustainability must include the enhancement of agricultural productivity. At present, the concept of sustainability is more adequate as a guide to research than to farming practice.

REVIEW

Any definition of sustainability suitable as a guide to agricultural practice must recognize the need for enhancement of productivity to meet the increased demands created by growing populations and rising incomes. The sustainable agricultural movement must define its goals sufficiently broadly to meet the challenge of enhancing both productivity and sustainability in both the developed and developing world. I will illustrate the problems of achieving these goals with some historical examples.

Ambiguity About Technology

The productivity of modern agriculture is the result of a remarkable fusion of science, technology, and practice. This fusion did not come easily. The advances in tillage equipment and crop and animal husbandry which occurred during the Middle Ages and until well into the 19th century evolved almost entirely from husbandry practice and mechanical insight. The power that the fusion of theoretical and empirical inquiry has given to the advancement of knowledge and technology since the middle of the 19th century has made possible advances in material well-being that could not have been imagined in an earlier age.

These advances have also been interpreted as contributing to the subversion of traditional rural values and institutions and to the degradation of natural environments. They led, in the 1960s and 1970s, to the emergence of a new skepticism about the benefits of advances in science and technology. A view emerged that the potential power created by the fusion of science and technology is dangerous to the modern world and the failure of the human race.

This ambiguity about the impact of science and technology on institutions and environments has led to a series of efforts to increase the sensitivity of scientists and science administrators and to reform the decision processes for the allocation of research resources. These efforts have typically attempted to find rhetorical capsules which would serve as a banner under which efforts to achieve reforms might march. Among the more prominent have been "appropriate technology," "integrated pest management," "low-input technology" and, more recently, "sustainability."

Reforming Agricultural Research

It is not untypical for such rhetorical capsules to achieve the status of an ideology or a social movement while still in search of a methodology, a technology, or even a definition. If the reform movement is successful in directing scientific and technical effort in a productive direction, it becomes incorporated into normal scientific or technological practice. If it leads to a dead end, it slips into the underworld of science often to be resurrected when the conditions which generated the concern again emerge toward the top of the social agenda.

Research on new uses for agricultural products is an example. It was promoted in the 1930s under the rubric of chemurgy and in the 1950s under the rubric of utilization research as a solution to the problem of agricultural surpluses. It lost both scientific and political credibility because it promised more than it could deliver. It has emerged again, in the late 1970s and early 1980s, in the guise of enhancing value added.

The "sustainability" movement, like other efforts to reform agricultural research, has experienced some difficulty in arriving at a definition that can command consistency among the diverse and sometimes incompatible reform movements that are marching under its banner. Those of you who may recall the more populist conservation literature of the 1950s, such as *Topsoil and Civilization* (1955) by Tom Dale and Vernon Carter, or *Malabar Farm* (1947) by Louis Bromfield, will recognize the poetry that has emerged in some of the new sustainability literature. Fortunately, we can draw on several historical examples of sustainable agricultural systems.

Sustainable Agricultural Systems

One example of sustainable agriculture was the system of integrated crop-animal husbandry that emerged in Western Europe in the late middle ages to replace the medieval two- and three-field systems (Boserup, 1965). The "new husbandry" system emerged with the introduction and intensive use of new forage and green manure crops. These in turn permitted an increase in the availability and use of animal manures. This permitted the emergence of intensive crop-livestock systems of production through the recycling of plant nutrients in the form of animal manures to maintain and improve soil fertility.

A second example can be drawn from the agricultural history of East Asian wet rice cultivation (Hayami and Ruttan, 1985). Traditional wet rice cultivation resembled farming in an aquarium. The rice grew tall and rank; it had a low grain-to-straw ratio. Most of what was produced, straw and grain, was recycled into the flooded fields in the form of human and animal manures. Mineral nutrients and organic matter were carried into and deposited in the fields with the irrigation water. Rice yields rose continuously, though slowly, even under a monoculture system.

A third example is the forest and bush fallow (or shifting cultivation) systems practiced in most areas of the world in pre-modern times and today in many areas of tropical Africa (Pingali, Bigot, and Binswanger, 1987). At low levels of population density, these systems were sustainable over long periods of time. As population density increased, short fallow systems emerged. Where the shift to short fallow systems occurred slowly, as in Western Europe and East Asia, systems of farming that permitted sustained growth in agricultural production emerged. Where the transition to short fallow has been forced by rapid population growth, the consequence has often been soil degradation and declining productivity.

Sustaining and Enhancing Productivity

This brings me to the title of this paper. The three systems that I have described, along with other similar systems based on indigenous technology, have provided an inspiration for the emerging field of agroecology. But none of the traditional systems, while sustainable under conditions of slow growth in demand, has the capacity to respond to modern rates of growth in demand generated by some combination of rapid increase in population and in growth of income. Some traditional systems were able to sustain rates of growth in the 0.5 to 1.0% per year range. But modern rates of growth in demand are in the range of 1.0 to 2.0% per year in the developed countries. They often are in the range of 3.0 to 5.0% per year in the less developed and newly industrializing countries; rates of growth in demand in this range lie outside of the historical experience of the presently developed countries!

In searching the literature on sustainability, I do not find sufficient recognition of the challenge that modern rates of growth in demand impose on agriculture. If the concept of sustainability is to serve as a guide to practice, it must include the use of technology and practices that both sustain and enhance productivity.

In the United States, the capacity to sustain the necessary increases in agricultural production will depend largely on our capacity for institutional innovation. If we lose our capacity to sustain growth in agricultural production, it will be a result of political and economic failure. Failure to reform agricultural commodity programs in a manner that will contribute to both sustaining and enhancing productivity will mean the loss of one of the few industries in the United States that has managed to retain world-class status—that is capable of competing in world markets (Ruttan and von Witzke, 1988).

It is quite clear, however, that the scientific and technical knowledge is not yet available that will enable farmers in most tropical countries to meet the current demand their societies are placing upon them nor to sustain the increases that are currently being achieved. Further, the research capacity has not yet been established that will be necessary to provide the knowledge and the technology. In these countries, achievement of sustainable agricultural surpluses is dependent on advances in scientific knowledge and on technical and institutional innovation.

Implications for Research

I am deeply concerned that the commitment to support the development of the research capacity in both developed and developing countries that will be necessary to achieve productive and sustainable agricultural systems has been weakening. And I am also concerned that the sustainability movement is pressing for adoption of agricultural practices under the banner of sustainability before either the science has been done or the technology is available.

It has been surprisingly difficult to find careful definitions of the term sustainability. This is at least in part because "sustainability," if it is to provide a useful rhetoric for reform, must be able to accommodate the several traditions that must march under its banner. These include the organic agriculture tradition, the land stewardship movement, the agroecology perspective, and others. In my judgment, any attempt to specify the technology and practices that meet the criteria of sustaining and enhancing productivity would be premature. At present, it is useful to define sustainability in a manner that will be useful as a guide to research rather than as an immediate guide to practice. As a guide to research, it seems useful to adhere to a definition that would include: (a) the development of technology and practices that maintain and/or enhance the quality of land and water resources, and (b) the improvement in plants and animals and the advances in production practices that will facilitate the substitution of biological technology for chemical technology.

Furthermore, it is desirable to generate the knowledge that will enable us to determine what it is possible to achieve in the direction of the above objectives primarily from a biological perspective. Maximum yield experiments represent a useful analogy. The objective of a maximum yield experiment or trial is not to provide a guide to farm practice. Rather it is to find out how a plant population performs under high level input stress. The research agenda on sustainable agriculture needs to define what is biologically feasible without being excessively limited by present economic constraints.

Literature Cited

Boserup, E. 1965. *Conditions of Agricultural Growth*. Aldine Publishing Company, Chicago, Illinois.

Bromfield, L. 1947. *Malabar Farm*. Harper, New York, New York.

Dale, T., and V. G. Carter. 1955. Topsoil and Civilization. Oklahoma University Press, Norman, Oklahoma.

Hayami, Y., and V. W. Ruttan. 1985. *Agricultural Development: An International Perspective*. The Johns Hopkins University Press, Baltimore, Maryland. Pp. 280-298.

Pingali, P., Y. Bigot, and H. P. Binswanger. 1987. *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa*. The Johns Hopkins University Press, Baltimore, Maryland.

Ruttan, V. W., and H. von Witzke. 1988. *Toward a Global Agricultural System*. Interdisciplinary Science Reviews (in press).

Comment on *Alternative Agriculture* Systems

Luther Tweeten
Anderson Professor, Department of Agricultural Economics
The Ohio State University
and
Glenn A. Helmers
Professor, Department of Agricultural Economics
University of Nebraska, Lincoln

SUMMARY

In *Alternative Agriculture*, there was little discussion of tradeoffs in national goals resulting from widespread and rapid adoption of low input agricultural practices. Using a University of Nebraska study and assuming no changes in present commodity programs, the impact on agricultural production, product market prices, and net returns to farmers are analyzed for low input cropping systems. One analysis assumed that only a few farmers adopt low input alternatives, while a second analysis assumed all farmers adopt low input alternatives. Acting alone, a farmer would experience income losses from low input alternatives. Under widespread adoption of low input alternatives, output was significantly reduced (up to

25%), product market price increased (up to 87%), and net returns increased in the short run.

REVIEW

Goals shared by many Americans are a clean and safe environment (food safety, soil conservation, and groundwater quality), low costs of farm programs to taxpayers, farm income sufficient to maintain a family farm structure, reasonable food and fiber costs to consumers, and international competitiveness to earn foreign exchange.

Economists are not especially adept at weighing these goals to say which farm policy is best. Rather their role is to show implications of policies, highlighting tradeoffs between the various goals of farm policy. *Alternative Agriculture*, the report of the National Academy of Sciences panel, provided limited information on such tradeoffs. This note highlights findings from a recent study providing information on some tradeoffs needed by the public to make decisions through the political process. Although only a beginning and in need of supplementation from in-depth studies for numerous resource situations throughout the nation, the findings from Nebraska make several points to ponder.

Table 1 illustrates these points. Basic data are from a University of Nebraska study for a cornbelt farm (Sahs et al., 1988). System (1) which is a row crop rotation of corn and soybeans is considered here to represent conventional agriculture.

Gross receipts are found by multiplying the prices given in the footnote times production on 600 acres at the yields indicated in the table. Variable operating costs are lower for the alternative agriculture rotations (3), (4), and (5) than for the conventional rotation (1) when compared in a consistent manner. In the study, straw harvesting was charged a custom rate which "masks" the tendency for the alternative agricultural systems to have lower variable costs compared to the conventional system. This pattern of lower variable operating costs for alternative agricultural systems has been apparent in some other studies.

If a few scattered farms adopted the respective low-input rotations and practices, prices would not change. Under scenario 1, costs do not fall as much as receipts with the low-input rotations so net receipts and net returns to overhead labor and management fall sharply for the presumed 600 acres. If scenario 1 conditions hold, few farmers will adopt alternative agriculture systems because it will not pay to do so. Commodity deficiency payments for feedgrains are excluded from the study. However, the study period covered 1978 to 1985 and commodity policy directly impacted market prices during this period more than recently.

The assumption in scenario 2 is that all farmers adopt each respective rotation and that the rotations represent what is happening in the nation. Aggregate output (measured by constant-dollar output = acres x yield x constant dollar prices) falls 11% with rotation (2), 24% with rotation (3), 26% with rotation (4), and 24% with rotation (5). In the 3 to 5 year length of run considered, each 1% reduction in national output raises prices 3.3% (an aggregate price elasticity of demand of –0.3 which is consistent with estimates from various sources of the demand for feed grains and soybeans in the intermediate run). The result in scenario 2 is to raise receipts in

Table 1. The micro and macro economics of low-input rotations in Nebraska

Item	Crop rotations[a] C-Sb (1)	GS-Sb (2)	C-Sb-C-O (3)	C-Sb-C-O (4)	C-Sb-C-O (5)
Herbicide	Yes	Yes	Yes	No	No
Insecticide	Yes	Yes	No	No	No
NPK source	Fertilizer	Fertilizer	Fertilizer	Fertilizer	Manure
10-year average yields					
Corn/grain sorghum	108.7	88.3	90.5	86.6	84.4
Soybeans	38.0	41.4	37.1	37.0	33.9
Oats	—	—	60.4	60.3	64.6
Acres (assumes 600 acres)					
Corn	300	—	300	300	300
Grain sorghum	—	300	—	—	—
Soybeans	300	300	150	150	150
Oats	—	—	150	150	150
Scenario 1: Results if only a few farmers adopt alternative agriculture					
Gross receipts ($)[b]	151,179	133,899	114,652	111,614	114,633
% change from C-Sb	—	-11.43	-24.16	-26.16	-24.17
Variable costs ($)	46,179	30,699	47,452	42,614	45,633
Net return above variable costs ($)[c]	105,000	103,000	67,200	69,000	69,000
Fixed costs ($) (land and machinery ownership)	75,000	75,000	75,000	75,000	75,000
Net return to overhead labor and management ($)	30,000	28,200	-7,800	-6,000	-6,000
Scenario 2: Results if all farmers adopt respective rotations					
% change in prices	—	38.10	80.53	87.20	80.57
Gross receipts ($)	151,179	184,915	206,981	208,941	206,993
Variable costs ($)	46,179	30,699	47,452	42,614	45,633
Net return above variable costs ($)	105,000	154,216	159,529	166,327	161,360
Fixed costs ($)	75,000	75,000	75,000	75,000	75,000
Net return to overhead labor and management ($)	30,000	79,216	84,529	91,327	86,360

Source: Sahs, W. W., G. Lesoing, G. A. Helmers, and J. E. Friesen. 1988. Crop production in a rotational system compared with mono-cropping. Paper presented at American Society of Agronomy meeting, Garden Grove, California, November 28-29, 1988.

[a] C=corn, Sb=soybeans, GS=grain sorghum, O=oats/sweet clover. Yields from 1978 to 1985/1987. Site is Mead, Nebraska. Oats straw, 100 bales per acre, market value.

[b] Average prices per bushel: corn $2.50, soybeans $6.11, grain sorghum $2.19, and oats $1.41. CPI adjusted 1985 base. No government payments. Manure cost 50% of NPK fertilizer; 8.5 tons on corn, 6 tons on oats.

[c] Including costs of direct labor.

cases (2) through (5) above those of the conventional rotation (1). Net returns above variable costs (including costs of direct labor) increase and returns to overhead labor and management increase by two to three times compared to rotation (1). An assumption of a $75,000 charge for land and machinery ownership costs is included.

The analysis illustrates the important principle that widespread adoption of practices of alternative agriculture such as possible under the 1990 farm bill could substantially reduce food output and raise prices and farm gross and net income in the intermediate run. Widespread adoption of alternative agriculture practices would reduce food output (up to 26% using the example herein) and could place a severe burden on budgets of low-income consumers. Food shortages could sharply increase in less developed countries even if only developed countries adopted alternative agriculture systems.

Also, the results show that producers presently do not have economic incentives to adopt many low-input systems unless they are forced to.

This analysis has serious shortcomings:

1. Nebraska results may not generalize—data such as in the table are needed for more resource situations around the country.

2. Not all farmers will adopt low-input practices even if pushed by provisions of the 1990 farm bill.

3. The manure-fertilizer rotation is not feasible for all farms. Manure would have to be purchased for some farms and costs of transportation of manure are high. Many farmers would likely not go to a livestock system. Farms that produce most of our fruits, vegetables, fibers, sugar, and rice are not well-suited for such systems.

4. Variable and overhead costs are assumed to be unchanged in the example with widespread adoption of alternative low-input rotations. Variable costs could rise as manure prices are bid up. On the other hand, chemical prices could fall as many farmers cut use.

5. Widespread adoption of low-input rotations involves various equilibria adjustments in the longer run. One is demand elasticity adjustments from those assumed here. Another is input substitutions which reduce the output impacts described here. Finally, one of the laws of economics widely observed over the years is that land prices adjust to capitalize pure profits. Hence with time, overhead costs would rise so that profits would be about the same for the industry with or without low-input agriculture.

6. Results are sensitive to the nature of existing commodity programs. Presently commodity programs tend to benefit program crops. Changes in this (such as greater crop flexibility while retaining deficiency payments) increase the relative economic ranking of lower input systems compared to the results of this study.

7. Agricultural management specialists suggest that most alternative agriculture systems are more demanding of operator management and time than conventional systems. Hence, able operators might do better

with low-input systems than suggested by the table while less able managers may experience less favorable outcomes.

Conclusions

1. Many alternative agriculture systems are unprofitable to individual farmers. While there are some farmers who presently practice some or all aspects of alternative agriculture, on the whole they must weigh the bottom line of profit carefully for economic survival and will not adopt practices that entail a significant sacrifice of profit.

2. Many alternative agriculture systems sharply reduce agricultural output in the intermediate run. To maintain current food and fiber output would require a substantial additional commitment of conventional production resources such as land and labor.

3. If all farmers were required to follow alternative agriculture systems such as outlined in this example from Nebraska, food and fiber prices would rise to make such systems profitable to farmers, but food and fiber costs to consumers would rise considerably. Of course, it is up to society to determine whether improvements in the environment from alternative agriculture systems are worth the reduced production and associated higher food and fiber prices. In the longer run additional resources would be drawn into agriculture moderating the output and price consequences reported here. It also should be noted that some parts of alternative agriculture systems such as conservation tillage and "best management practices" of integrated cost management are already being used by many farmers in the nation.

8

Plant Protection

Alternative Agriculture
Whose Perspective

John R. Abernathy
Professor of Weed Science, Resident Director of Research
Texas Agricultural Experiment Station
Lubbock

SUMMARY

Real world producers are concerned about their environment, family health, water quality, and sustainability of their land and livelihood, yet these vital producers of our nation's food and fiber are the recipients of criticism for an unfounded perception of groundwater contamination and food safety. The tone and direction of this document based on example farms and testimonials, if followed, will seriously jeopardize the ability of the U.S. producers to provide adequate food and fiber. Research is currently underway to provide more profitable, efficient, and environmentally sound agricultural systems.

REVIEW

The producers that provide the food and fiber for the United States and much of the world today are concerned about their environment, their livelihood, health of their families, and the quality of their water. Yet these producers and agricultural enterprises are receiving unjust criticism for a perception of groundwater contamination and food safety. In dealing with real world farm operators, I assure you that their interests are for the future, to provide and to turn over their land to their children, and to insure sustainability of their farms for many, many years. They have always had this concern.

There is no doubt that we in agriculture want to develop more efficient, environmentally sound practices than are currently used. We must develop "best management practices" and we must continue to provide leadership, profitability, and sustainability for our producers. By the same token, we must substantiate and provide for our nation's security, a food and fiber supply that is adequate. If the examples and tone contained in *Alternative Agriculture* were used by all of agriculture, the United States could jeopardize sustaining the fantastic agricultural machine that has been developed during the last 50 years.

Sustainability to farmers is not a new term. In real world agriculture, many farmers in the last 10 to 15 years have seen the need to cut back on inputs in almost every phase of their agricultural production scheme. We in the agricultural research community have been providing these farmers with technology to reduce inputs. For many years, it has been our philosophy to provide increased profitability for Texas farmers through reduced inputs as well as through increased yield potentials.

The National Research Council's report *Alternative Agriculture* stimulates thought provoking ideas, presents challenges, and illustrates the lack of alternative systems for future agriculture of the United States and the world. Clearly, we must develop new agricultural systems and technology as agriculture moves toward the 21st century. It is disturbing, however, that this document based primarily on limited and inadequate data from a few farms would be used to support the reduction or elimination of chemical inputs in agriculture.

Speaking as a weed scientist, today it would be virtually impossible except on a limited basis to control weeds in crop production without the use of herbicides. Indeed, several of the contributors to the NRC report cite this need. Biological control methods are proposed to replace chemicals in the future. Yet, after 30 years of research, especially in weed control, only a few success stories have emerged for biological control mechanisms. Commercial industry cannot afford to develop them in today's economic conditions. There is only limited research money provided for development of biological control mechanisms within our current federal and state research organizations.

I am in total agreement with the recommendation that our agricultural research needs to be coordinated in a multiple disciplinary systems approach in real farm situations. The Texas Agricultural Experiment Station is providing leadership in farming systems research which links science with extension through on-site farm field research for validation of basic through applied programs.

During my early childhood years, while hoeing weeds out of cotton on a farm in Oklahoma, I decided that I wanted to make contributions to agriculture which would make life better for everyone. My colleagues and I who serve this great industry of agriculture today are very proud that we have made major contributions to alleviate the toil, expense, and drudgery of agriculture by providing environmentally sound pest control systems for most of our crops grown in the United States today.

Alternative Agriculture
Proceed with Caution

Robert M. Devlin
Professor, Cranberry Experiment Station
University of Massachusetts at Amherst

SUMMARY

We all should take note that in the first quarter of the twentieth century, crop yields in the United States were comparable to that of other nations throughout the world. In the years that followed, especially in the 1940s, 1950s, and 1960s, university and U.S. Department of Agriculture scientists, government farm policies, and the pesticide industry helped the American farmer to far exceed the crop yields of his counterpart worldwide. In fact, the strong foundation upon which America stands has essentially been built by the hard labor and expertise of its farmers and agricultural scientists. We feel secure in the knowledge that we can feed ourselves—that we do not rely on other nations to keep the threat of malnutrition and starvation from our door. The question is, "Do we want to tamper with a system that has given us so much and has worked so well?"

We should be very careful of making any sweeping changes in our agricultural systems. Rather, let us proceed with caution and determination to protect our farmers as well as our environment. Both are important. Remember, not only our farmers' livelihood is at stake, but also the quality of life of the many people that rely on American agriculture to feed and clothe them.

REVIEW

The National Research Council (NRC) has published a report entitled *Alternative Agriculture* that stresses the importance of establishing alternative agricultural systems to replace our present system of farming. The NRC points out that conventional farming techniques are allowing alarming amounts of top soil erosion, polluting our water supplies, and contaminating our food supplies. According to the report, federal commodity programs encourage agricultural practices that aggravate these problems.

What the NRC says is mostly true. Soil erosion and water pollution are big problems that need to be attended to. Contamination of our food supply with pesticides and animal drugs is rare and not really a problem. What the NRC recommends to alleviate these problems are a variety of alternative farming systems variously referred to as organic, regenerative, low input, sustainable, and biological. They offer case studies that suggest that alternative agriculture can be competitive with conventional agriculture.

The NRC's observations in this respect are suspect. It has not been really proven that alternative agricultural methods are more profitable than conventional methods. Indeed, it seems the opposite is true. For example, if we were to prohibit cosmetic applications of pesticides, grading standards for our fruit and vegetables would have to be lowered. This, in turn, would not allow our produce to compete in the world market. Obviously, this low input method would be unprofitable for the American farmer.

We should be very careful of making any sweeping changes in our agricultural systems. Rather, let us proceed with caution and determination to protect our farmers as well as our environment. Both are important. Remember, not only our farmers' livelihood is at stake, but also the quality of life of the many people that rely on American agriculture to feed and clothe them.

Comments on *Alternative Agriculture*

Don W. Dickson
Professor, Entomology and Nematology Department
Institute of Food and Agricultural Sciences
University of Florida

SUMMARY

The report contained only a brief assessment on alternatives for nematode control. Many of the ideas presented were partially inaccurate and misrepresented basic nematological strategies for nematode management. The implication was that growers have many easily adopted options for nematode management, besides nematicides. But, without major changes in government policies, growers will not readily accept control tactics such as crop rotations. Unless there is a major breakthrough, biocontrol of nematodes is years away from development. Gains have been made in genetic resistances, but nematode diversity and polyspecific communities of nematodes limit its usefulness. More research must be done on integrating nematode management strategies.

REVIEW

The committee on the role of alternative farming methods in modern production agriculture established lofty and worthy objectives and goals for sustaining and enhancing agriculture for the future. A thorough job was done on studying and reporting on the sciences and policies that influence our present-day farming practices. But it quickly becomes obvious, when reading the committee's report, that a critical review by a large segment of the agricultural scientific community is needed. My comments will focus on the committee's statements on alternative nematode control. Unfortunately, the committee's statements on this small portion of the report are too brief and, of even greater concern, they are inaccurate and show a lack of understanding of basic nematological practices and strategies for managing nematodes.

Specific statements that must be addressed include:

1. "Nematode control is particularly difficult." The use of the term 'control' implies an impossible degree of dominance by man (see J. L. Apple, *In:* Horsefall and Cowling, Eds., *Plant Disease, An Advanced Treatise*. 1978). The term 'control' should be limited in use to describe specific tactics that are applied to reduce or eliminate nematodes, whereas the term 'management' should be reserved for multiple tactics that are employed to combat nematode infestations (see I. J. Thomason and E. P. Caswell, *In:* Brown and Kerry, Eds., *Principles and Practice of Nematode Control in Crops*. 1987). In future alternative agriculture programs, we must address nematode management, not nematode control. It is very important that growers be taught that single, quick remedy tactics such as nematicide applications are not as suitable for sustainable agriculture as employing several management practices that would help keep nematodes at low population densities.

2. "Genetic resistance is successful in only a few cases." Although it is debatable what is meant by 'few cases', there has been great success in plant breeding programs, whereby nematode resistance has been incorporated into many agriculturally accepted cultivars. Sasser and Kirby (Crop Cultivars Resistant to Root-Knot Nematodes, *Meloidogyne* Species. IMP publication, North Carolina State University, Raleigh, N.C.) list ten plant families, 27 crops, and 94 cultivars with resistance to the root-knot nematode group. There are many other plants with resistance or tolerance to other important plant-pathogenic nematodes.

3. "Genetic research to develop nematode-resistant cultivars has been successful in sugar beets and tomatoes." Although resistance to the root-knot nematode group has been incorporated into many tomato cultivars, the resistance is broken by high soil temperatures. This renders the resistance useless in the deep South, where a large portion of the tomato industry exists.

4. The committee states "Rotating corn with soybeans will control most nematode problems." In fact, corn is a good crop for increasing a wide range of plant-parasitic nematodes, viz. root-knot, sting, stubby-root, lesion, and ring nematodes. Corn in rotation with soybean will reduce the population densities of the soybean cyst nematode. Although the soybean cyst nematode is a very important pest of soybean, it is hardly the only important nematode pest of soybean.

5. The committee reports that *Pasteuria penetrans* (a bacterial spore parasite of nematodes) is effective against several economically important nematodes and that "it is expensive to produce on a large scale." In fact, it has never been shown pragmatically to effectively control any economically important nematode. Very limited laboratory studies do show that the microorganism has great potential as an antagonist of plant-parasitic nematodes. It has not been cultured; thus, it cannot be produced on a large scale. It can be reared only on specific nematodes in plant-nematode culture or in excised root-tip-nematode culture. Only small quantities of the bacterium can be produced by either technique. As a result, field research on the economic benefits of *P. penetrans* is very limited.

6. "A less expensive, but also less effective, biological control option is the use of plants such as *Crotalaria spectabilis* that prevents the nematode from reproducing." This is not a viable option, because the plant species is regulated and cannot be grown because the seeds are toxic to livestock. There are several plant species that produce substances that affect nematodes in a negative way, but these remain scientifically important; not options for farmers.

7. Two other seriously flawed statements by the committee are about using Coastal Bermudagrass to control nematodes. The first is that the grass can be incorporated before planting lespedeza, tobacco, or vegetable transplants to protect against nematodes. While adding green manure does cause some suppression of nematodes, it is not a reliable nematode management technique. Incorporating Coastal Bermudagrass soon after it is planted would hardly be considered an economically feasible control tactic because of the large expense of establishing the crop. Several pasture grasses exist, including Coastal Bermudagrass, that make excellent rotational crops. But for them to be effective, they must be grown for a minimum of 4-6 years before they are plowed under. Also, the grasses must be grown relatively weed-free in order for them to effectively reduce plant-parasitic nematodes. Many weeds are excellent host for nematodes.

   The second statement is that "Bermudagrass will also reestablish itself after the annual crop is harvested." In warm season climates, Bermudagrass will reestablish very quickly (2-3 weeks) and becomes a serious weed problem unless special precautions are taken before it is plowed under or it must be cultivated regularly throughout the growing season. This is the main reason many growers refuse to plant annual crops in established stands of Bermudagrass. Herbicides are available to kill Bermudagrass, but these are expensive and add pesticide load to the environment.

   Crop rotations are among the best methods of soilborne disease control. Bermudagrasses, bahiagrasses, pangolagrass, and other pasture grasses and leguminous crops should be more widely adopted, but as one Florida county agent said, "They are darn expensive nematicides." Government policies and programs do not encourage growers to establish long-term (4-6 years) rotations with these crops. There must be monetary incentives to keep land in pastures.

If alternative agriculture is to be implemented on a meaningful scale and within a reasonable time frame, then there must be a great deal more research done that deliberately integrates systems essential to the success of the program. As pointed out in the report, research programs are not currently funded in a manner that achieves interdisciplinary research. In fact, most granting programs dampen interdisciplinary research because of the keen competition and low budgets granted. This is underscored by a review of the USDA Competitive Grants Program. Furthermore, interdisciplinary research means multi-authorships, a practice not greatly appreciated in annual evaluations and tenure and promotion files. The report failed to place enough emphasis on this very important fact.

If we are to build a sustainable and enhanced agriculture system that makes timely and significant improvements, then immediate changes in funding agricultural research and extension programs must be made. One in the scientific field sees the immediate needs for redirecting funding for research to encourage interdisciplinary or systems research.

Comments on *Alternative Agriculture*

Richard S. Fawcett, Ph.D.
Fawcett Consulting
Huxley, Iowa

SUMMARY

The report *Alternative Agriculture* suggests a system rather than an end result as a goal for American agriculture. Rather than concentrating on an ultimate goal of improved protection of the environment, sustainability of agriculture, human health, and farm profitability, a goal of adopting alternative agriculture systems is proposed with very little evidence that the system will in fact result in the desired improvements. Only by realizing that all farming practices and systems have positive and negative impacts and by selecting practices based on their merits, unrestrained by a system goal that limits the tools that can be used, can an ultimate goal of improvements in environment, health, and sustainability best be met.

REVIEW

The report *Alternative Agriculture*, is unusual for a scientific report, in that a system rather than an end result is suggested as a goal for American agriculture. Rather than identifying an ultimate goal of improved protection of the environment, sustainability of agriculture, human health, and profitability of farms, a goal of adopting a specific farming system is proposed with very little evidence that the proposed system will in fact result in the desired improvements. The report does not clearly acknowledge that all practices and inputs in agriculture, whether alternative or conventional, have positive and negative impacts on the environment, the consumer, and the farmer. Only by selecting practices based on their merits, unrestrained by a system goal that limits the tools that can be used, can an ultimate goal of improvements in environment, health, and sustainability best be met. If practices and systems are simply chosen based on their merits, there is no need to label them as alternative or conventional.

The debate which this report will likely spur will center around whether American agriculture should continue with its current evolution as it adopts practices developed through research to better address concerns such as environmental contamination, sustainability, and human health, or whether more radical changes are needed. Most readers of this report and the media will conclude that the report advocates adoption of "alternative agriculture," although specific committee recommendations are more modest, mainly calling for more research to develop alternative systems. The report raises the concern that federal commodity programs greatly limit farmers' cropping choices and sometimes have counterproductive effects on the environment. This valid concern needs to be addressed in federal farm legislation.

I have some difficulty in articulating just what this new system of alternative agriculture is and how it differs from "conventional agriculture" (which is not defined in the report). The definition of "alternative" when used as an adjective is: "(of two things) mutually exclusive, so that if one is chosen the other must be rejected." What is mutually exclusive about alternative agriculture? On page 4, the report defines alternative agriculture as any system which pursues goals of more incorporation of natural processes, reduction in use of off-farm inputs, greater use of biological and genetic potential of plant and animal species, improvement in matching cropping patterns to productive potential of land, and improved conservation of soil, water, energy and biological resources.

Since all farming systems use natural processes and genetic potential, match crops to soil potential, and conserve resources to some extent, these goals do not make alternative agriculture unique or mutually exclusive from conventional agriculture. Farms which use "more" of these are defined as "alternative." More than what? No baseline of comparison or ultimate goal is defined. The goal of reducing off-farm inputs could be classified as being unique, although no farmer likes to spend money on inputs unless he/she is convinced that the expenditure will increase profits or produce some other benefit. Off-farm inputs have generally declined in recent years with improvements in technology and our understanding of biological and physical systems. Difficult economic times for farmers in the 1980s forced them to carefully consider the economics of all purchases and resulted in some reductions. Recently, heightened concern among farmers about environmental issues has led to reductions in certain inputs, notably nitrogen fertilizer, for environmental reasons. For example, since 1980 fertilizer use by U.S. agriculture has declined by 15%, insecticide use by 40% (partially due to IPM programs), and herbicide use by 20%. Probably the biggest reduction by farmers in the Midwest has been a reduction in tillage and fuel use. Many farmers have reduced tillage trips by half or more. But reducing off-farm inputs as a goal, *per se*, is a goal unique from traditional agriculture.

Perhaps the committee's definition of "alternative" agriculture is best illuminated by examining the eleven anecdotal case studies for their characteristics. Many, in fact most, of the practices used by these farms are not unique, but are common to most farms. IPM use (including pesticide use) was documented on many of the case study farms. The IPM system began its development over 20 years ago due largely to concerns about the unintended impacts of extensive insecticide use, including environmental contamination and pest resistance. Adoption of IPM is an example of how agriculture has changed in response to concerns. Some case study farms do not participate in government farm programs (a topic I will discuss later) and practice more crop rotation. But the only truly unique feature of a few of these case studies is that they use no or very little pesticide and fertilizer. The reduction or elimination of some purchased (usually man-made) inputs such as pesticides and fertilizers seems to be the only easily identifiable difference between "alternative" and "conventional."

What is the reason for the goals defined for alternative agriculture? Are the goals such as reduction of purchased inputs simply goals in and of themselves, or are they means to another goal or result. The committee outlines current problems and concerns with U.S. agriculture such as environmental contamination, soil erosion, food safety, and human health. Presumably the ultimate goal of changes in agriculture is to improve environmental protection, human health, and sustainability and profitability of farms. Curiously, little or no data is presented to show that alternative farming systems will meet this goal. The system has become the goal before we know if the system will meet our higher goal.

It is important to remember that all farming practices can have positive and negative impacts on the environment, the farmer, and the consumer. Negative impacts are not unique to man-made inputs. For example, the study repeatedly advocates the use of legumes and manure as nitrogen sources as an alternative to chemical fertilizer, implying that this could reduce the threat of contamination of groundwater by nitrate. Nitrate is produced through the nitrogen cycle from all nitrogen sources, including fertilizer, manure, and legumes. No evidence is presented that use of legumes and manure would reduce nitrate in groundwater. In fact, no documentation of nitrate levels in groundwater on case study farms was even attempted (a nitrate analysis of well water costs about $10).

From available evidence we know that it will be much more difficult to manage nitrate from legumes and manure than it is to manage fertilizer nitrogen. These sources may in fact present a greater risk to groundwater than efficiently used nitrogen fertilizer. This is not to say that there are no concerns about nitrogen fertilizer as it is currently used. Quite to the contrary, nitrogen fertilizer rates applied to crops such as corn have often been greater than economically optimal in the past either due to management deficiencies, or more commonly, because refined diagnostic techniques were not available. Also, economically optimal rates may still produce groundwater risks in vulnerable settings. However, new diagnostic techniques such as improved soil tests promise to allow farmers to sometimes reduce nitrogen fertilizer rates without sacrificing profitability. Nitrogen fertilizer is more easily controlled (in amount, form, and application timing) than legumes and manure.

Similarly, all pest management techniques have positive and negative impacts. The major alternative to herbicides for weed control is repeated tillage. Several of the case study farms tilled fields three to four times prior to planting, followed by three or four additional tillage operations after planting. Tillage, while effective in controlling weeds (unless wet weather prevents timely cultivation), has the negative impact of leading to soil erosion, one of the greatest environmental and sustainability problems of modern agriculture. Much of the progress in soil conservation made in recent years has been due to widespread adoption of conservation tillage systems, made possible by herbicides. These systems cause less soil disturbance and leave crop residue on the soil surface to protect against the erosive effects of rainfall and water runoff. Returning to a more tillage-intensive system would increase erosion. This would happen at a time when farmers must reduce erosion to compliance levels in order to participate in any government farm programs (support prices, insurance, loans, disaster relief, etc.).

On highly erodable cropland (25% of U.S. and 44% of Iowa cropland), farmers using tillage-intensive systems would not be in compliance unless they grew few row crops in rotations such as corn-oats-meadow-meadow-meadow or one year of row crop out of five. For most soils with 7% slope, the corn-soybean-corn-oats-meadow rotations described in the Midwest case study farms would not be in compliance due to excessive erosion, unless at least 35% residue cover was maintained and crops were contour planted. This allows only about one reduced tillage operation in soybean residue or two in corn residue. For most slopes of 11% and greater, a no-till system leaving 70% residue cover and disturbing less than 10% of the soil surface is required to plant corn and soybean rotations. In order to be eligible for federal farm programs, farmers must have now filed conservation plans, outlining soil conserving practices they will fully implement by 1995. These plans show that the majority of farmers plan to reduce tillage operations, adopting some form of conservation tillage.

Herbicide and insecticide use can harm nontarget organisms and sometimes result in detectable residues in water or food. Highly toxic products may threaten the health of applicators unless handling precautions are adequately followed. Intensive research and educational efforts are currently being directed at reducing these threats. Use of alternative pest management techniques, such as biological controls or breeding crops for pest resistance, can reduce pesticide use, but these alternative techniques also entail risks and trade-offs.

Use of pest resistant crops is very advantageous for farmers, since they do not have to buy or handle a pesticide. But this technique may produce risks for consumer health. The reason that a crop plant is resistant to a disease or insect is often due to the presence of natural pesticides produced by the plant. Breeding for resistance selects for higher concentrations of these chemicals, although the identity and properties of such chemicals are often unknown. Because these chemicals are produced by the plant, they are constantly present, often in the edible portions. Until recently, little thought has been given to potential human health impacts of breeding crops for pest resistance, although there are examples of new pest-resistant crop varieties causing acute human health problems (due to high concentrations of solanine and chaconine in potatoes, and psoralen in celery).

Biological controls often have the advantage of being host-specific, but biological controls must be very carefully tested before release to be certain that beneficial organisms will not be attacked, as these living organisms can multiply and spread. Once a release has been made into the environment, there is no turning back. Sometimes unintended negative impacts have arisen from the use of biological controls. For example, when I made the first release of the *Rhinocyllus conicus* seed weevil in Wisconsin in 1975, the insect was thought to be very specific in attacking musk thistle, a serious pasture weed. Today the weevil is known to attack the dune thistle, an endangered plant species.

There is currently renewed interest in allelopathy or the ability of plants to produce natural herbicides. It has been suggested that breeding crops for allelopathy or using allelopathic cover crops could be used to reduce herbicide-related concerns, such as groundwater contamination. However, there is no assurance that these allelopathic chemicals are any safer or more desirable than synthetic herbicides. Plants produce many very poisonous compounds as documented by voluminous research on poisonous plant species. Often crop plants come from the same plant families as poisonous species but have lower concentrations of the poisonous compounds. Certain natural organic acids derived from decomposing plant material have a deleterious effect on plant growth and have been identified in shallow groundwater in parts per million concentrations, or one thousand times higher concentrations than certain synthetic herbicides which have sometimes been detected in groundwater.

Many biological control and crop breeding techniques may in the end be more desirable alternatives than the use of pesticides, but we will never know until we subject them to the same scrutiny. Similarly, crop rotations and growing legumes may be the best cropping alternative in specific situations. What is critical is that scientists determine benefits and risks of all the alternatives, so that components of farming systems can be chosen based on their merits, rather than being constrained by a system goal which limits the tools which can be used. There will be some farmers who for philosophical reasons will choose to avoid some man-made inputs. Our research and education system should help them in meeting their goal, but should not advocate that system for all farmers.

The one committee recommendation with which I agree strongly is that federal commodity programs be restructured to allow farmers more flexibility in cropping decisions. Farmers don't grow monocultures because modern technology causes them to. They sometimes grow monocultures because government farm programs "tell" them to. Over the last several years in my former position as Extension Weed Specialist at Iowa State University, when I would suggest crop rotations to farmers as a means of improving weed control, almost universally the response would be: "I can't change my crop rotation because I will lose my corn base." Many economic analyses have shown that these farmers' concerns about their corn bases were well founded, as economic returns have consistently been higher when participating in farm programs. Farmers respond to economic signals, and the signals from the federal government have been heard loud and clear. Many of the concerns about modern agriculture which have been blamed on "technology," might more appropriately be blamed on counterproductive federal commodity programs. Monoculture crop production may be more feasible because of modern technology, but is not caused by technology.

The committee has helped to focus discussions by summarizing concerns about the present structure and impacts of agriculture and emphasizing the need for reevaluation and additional research, particularly interdisciplinary studies. The report has already stimulated healthy debate among scientists. However, the report may have unintended adverse effects in the public and political arenas.

While I do not believe that many committee members believe that elimination of pesticides and fertilizers from agriculture is either feasible or desirable, because of the consistent tone of the report, the public is left with the impression that elimination of pesticides and fertilizer is an appropriate goal in and of itself. Considering the speed with which actions are taken when public fears are fanned in the media (such as in response to concerns over Alar generated by the NRDC media campaign), there is a real danger that inappropriate and harmful actions could be taken. Such actions could produce great hardships for farmers, reducing rather than increasing environmental protection. Scientists have a responsibility to aid the public in understanding the benefits and risks of all agricultural techniques, so that informed decisions can be made. Agricultural scientists now face a great challenge to insure that the goal of agricultural research, education, and policy is to provide greater protection of the environment, human health, and farm sustainability and profitability rather than to adopt any particular system.

Alternative Agriculture
A Plant Pathologist's Review

Barry J. Jacobsen
Department of Plant Pathology
Auburn University

SUMMARY

The report, *Alternative Agriculture*, establishes noble goals for sustaining and enhancing agriculture for future generations. This report clearly implicates the negative effects of federal commodity programs in establishing crop rotations that enhance long-term productivity and profitability. The report also provides thought-provoking insight into the influence of science and public policy on farming practices and the agroecosystem. The discussion of alternative plant pathogen control and integrated pest management (IPM) leaves the uninformed reader with misimpressions and a naive concept of modern agroecosystems and plant disease control, in particular. The report summary provides a concise agenda for researching and implementing alternative agricultural strategies which will likely lead to long-term sustainability.

REVIEW

The committee on the role of alternative farming methods in modern production agriculture should be complimented for establishing noble goals for sustaining and enhancing agriculture for future generations in its report entitled *Alternative Agriculture*. This report clearly implicates the negative effects of federal commodity programs in establishing crop rotations that enhance long-term productivity and profitability. Further, the report identifies critical needs for research and extension programs and needed regulatory changes if American agriculture is to be competitive and sustainable in the long term. This report provides thought provoking insight into the influence of science and public policy on farming practices and the agroecosystem.

The section on alternative plant pathogen control and IPM was unfortunately too brief to provide a general understanding of current plant disease management concepts, hence compromising the ability of the typical reader to evaluate alternative plant pathogen control. The reader is left without a basic understanding of existing plant disease management concepts and their role in the modern agroecosystem. For example, the concept of utilizing several disease management practices in an integrated program is mentioned in only one paragraph. This ignores the fact that plant disease management for most crops is achieved by integration of the four principle disease control strategies; exclusion, eradication, protection, and use of disease resistant cultivars.

The report cited the use of disease resistant cultivars as "the proven alternative to chemical control." The authors recognized limitations such as pathogen variability and the methods to improve cultivar durability such as the use of cultivar mixtures, multilines, multigenic resistance, and horizontal resistance. However, the reader is left without the knowledge of the notable successes of single gene resistance in major cereal, oil seed, and vegetable crops. Nor is the reader informed of the limitations of multilines or horizontal resistance in crops where germplasm changes relatively rapidly. For example, the majority of modern corn hybrids have an economic life of approximately seven years. After this time they are replaced by newer, more productive, hybrids. The report also ignores the difficulty of incorporating multigenic resistance to several diseases into an individual hybrid cultivar. For example, some cucumber hybrids are resistant to six or seven different diseases. This would be a formidable task for a breeder who had to use multigenic resistance rather than single gene resistance.

The concept of utilizing modern molecular biological techniques to transfer genetic resistance is discussed briefly. However, the current restrictive regulatory and political climate are not acknowledged as barriers to the utilization of these exciting techniques. Limitations in plant regeneration, genetic material transfer, and maintenance of stable seed sources are not adequately addressed. The report does emphasize that better understanding of the genetic and molecular basis for disease promises to foster major improvements in genetic methods for disease control.

The authors stress the need to evaluate diverse germplasm for resistance genes; however, the large catalogued collections maintained by both government and private sources are ignored. It is clear to most modern plant breeders that existing cultivars have utilized only a small proportion of existing genetic material in present day cultivars. The report does acknowledge the relative lack of genetic diversity in many crop cultivars. The committee makes an interesting and important point that resistance to root diseases and the concept of root health are not fully investigated. Both of these factors will likely play a major role in sustainable agriculture systems.

Finally, the report would have readers believe that genetic resistance is only beneficial and has no costs. While this seems to be the case in many situations, host plant-produced compounds that contribute to resistance can have adverse toxicological consequences. For example, high concentrations of alkaloids in the late blight-resistant potato variety, Lenape, caused the variety to be withdrawn for food safety reasons. It is likely that closer evaluation of plant-produced compounds during this era of food safety concerns will identify other situations where disease resistance creates a food safety problem.

The authors cite several cultural controls; however they do not clearly show how these controls can be utilized in cropping systems involving a diversity of crops. For example, raising or lowering soil pH can control a disease in one crop only to make another disease more severe in another crop. The authors discussed pH effects but only in positive terms and not in cropping systems. The limitations of crop rotation and the negative effects of some rotations are largely ignored.

Discussion of chemical controls, like other control strategies, is somewhat superficial and dwells generally on negative implications of chemically-based disease control. For example, the report indicates that the need for disease control pesticides is based on concepts of intensive cultivation in monocultures, vulnerability of genetic resistance, and the need to produce blemish-free produce. The report ignores the need for fungicides to control endemic diseases for which usable genetic resistance is unavailable. The concept that disease control pesticides are used to meet the "blemish-free" USDA grading standard is misleading since these pesticides are used primarily to reduce losses both in the production field and postharvest environments. The authors clearly discuss health risks associated with chemical pesticides but ignore toxins (mycotoxins) produced by fungal plant pathogens which may represent a more serious health risk. This report also ignores the fact that market basket surveys clearly show that most fungicides can be used and still maintain the acceptable 1×10^{-6} oncogenic risk proposed in the Delaney Paradox report of the National Research Council. Also omitted are the regulatory problems associated with new fungicide registration and "minor crop" registration in the United States. Finally, this report suggests that postharvest fungicide treatments are used to control bacterial soft rot of potato induced by premarket washing practices. Clearly this is an error. Fungicides used postharvest in potatoes are used to control *Fusarium* decay problems.

Biological control of plant diseases is relatively well discussed with their potential and research needs identified. However, the relative specificity of biological controls is poorly discussed relative to the need to control a broad spectrum of pathogens in a variety of environments. Finally, regulatory restrictions involving the development, release, and ultimate utilization of biological control agents are ignored.

Of concern to this reviewer is the absence of discussion of other disease control strategies such as: pathogen exclusion by regulatory or other means, soil solarization or other methods for eradication of established pathogen populations, use of strategies for disease escape, use of environmental and plant-ontogeny-based disease prediction or economically based IPM decision aids, alternate host management, seed or propagation material testing, and many other strategies. This reviewer knows of few, if any, crop disease management programs that are based on only one or two strategies. Plant pathologists have historically used an integration of diverse strategies since we have never had a "silver bullet" for control of all or most diseases of a crop without disturbance of the ecosystem.

Another concern is the frequent mention of the southeastern and eastern U.S. as areas where fruit and vegetable production utilizing alternative agriculture techniques would be difficult. It is clear to this author that plant diseases (albeit different diseases) cause significant losses in all areas of the United States. While foliar diseases are often minimal in dry areas utilizing surface irrigation, soilborne and insect-vectored pathogens are often more serious in these environments. It is clear that if fungicide inputs are minimized in the hot, humid Southeast, alternative strategies such as disease resistant varieties, rotations, soil solarization, and biological controls would receive greater emphasis. If the intent of the report were to suggest that fruit and vegetable production be moved to areas of low rainfall and humidity, the authors failed to understand the increased demand on limited water resources, increased soil salinization, and the economic and environmental costs associated with transport of produce back to populations in humid areas. This is but one small example of the system complexities which must be addressed by several disciplines if alternative agriculture is to be successfully implemented. We must reorient discipline-based research to a systems-based research if alternative agriculture production is to be economically and environmentally sustainable. This report points out the need to change research funding if an interdisciplinary systems approach is to be achieved.

Undoubtedly the need for a concise discussion due to print and time allocations limited the authors in the depth of their discussion of plant disease management. The superficial nature of the discussion of IPM and alternate plant pathogen management leaves nonagriculturalists with misimpressions and a naive concept of modern agroecosystems and plant disease control in particular. The fact that individual plant pests and IPM were discussed separately demonstrates the difficulty of establishing an understandable systems approach recommended by this book.

The authors should be complimented for a well written executive summary. The summary provides a concise agenda for researching and implementing alternative agricultural strategies which will likely lead to long-term sustainability. The book, *Alternative Agriculture*, is thought provoking and should be read by anyone interested in food, fiber, and shelter now and in the future. The anecdotal examples of farms utilizing alternative agriculture concepts are enlightening and offer evidence that food can be economically produced in alternative farming systems. These examples, however, do not prove that these systems can be applied over large areas nor that they are sustainable.

Comments on *Alternative Agriculture*

Ellery L. Knake
Professor, Weed Science Research and Extension in Agronomy
University of Illinois at Urbana-Champaign

REVIEW

Comments

1. "Alternative agriculture" should not be interpreted as returning to "the way grandpa farmed" or a completely new system. The major theme should be resource conservation with more judicious selection and use of both chemical and nonchemical agricultural practices in a complementary manner.
2. Low-till and no-till programs which help conserve soil and nonrenewable energy resources do not necessarily require increased use of herbicides or higher costs.
3. Rotation of tillage and pesticides as well as crops should be encouraged as a means to reduce inputs, avoid pest resistance that could require more pesticide use, and help assure sustainability.
4. Increased emphasis is needed by the Cooperative Crop Reporting Services on surveys to monitor pesticide use, tillage, and cultural practices. A well coordinated effort is needed involving the Economic Research Service,

Agricultural Research Service, Agricultural Stabilization and Conservation Service, and Extension.

5. Increased emphasis is needed on crop management systems such as Integrated Pest Management and Expert Systems to add greater precision, decrease inputs, increase net returns, optimize efficiency, and assure sustainability.
6. Alternative farming practices can best be established through the well established research and technology transfer (Extension) system that has proven so successful. Rather than attempting to circumvent this system, appropriate liaison should be encouraged among the various interest groups.
7. Integrated Pest Management, Pesticide Applicator Training, and Pesticide Impact Assessment Programs should be made more permanent to add greater emphasis and continuity for even greater contributions to assuring sustainability.

Abstract

The NRC report on *Alternative Agriculture* is very timely and stimulates additional considerations to help assure conservation of resources and the sustainability of agriculture. Alternative agriculture must not be interpreted as nonchemical agriculture or as "returning to the way Grandpa farmed." Farmers will continue to use both chemical and nonchemical methods in a complementary manner, but with greater precision and more judiciously.

As the Soil Conservation Service (SCS) and Agricultural Stabilization and Conservation Service (ASCS) increase involvement in pest management and water quality programs, there should be close coordination with other agencies and organizations. There is very significant opportunity for the ASCS to encourage or require improved vegetation management on over 50 million acres of land set aside from production. Rather than allowing weeds and other undesirable organisms to proliferate and create a need for greater pesticide use, good vegetation management with desirable plant species can provide good weed control, encourage beneficial predators and other desirable organisms, contribute to improved water quality, and provide nitrogen from legumes, as well as help conserve soil and encourage wildlife. With slight change in policy, benefits from set-aside could greatly multiply with little or no added expense to the government or farmers.

Although about two or three decades late, the Cooperative Crop Reporting Services should be commended for realizing that pesticide use surveys are essential for planning and evaluating such programs as Pesticide Applicator Training, Pesticide Impact Assessment, IPM, and improved water quality. They should also increase emphasis on monitoring changes in farming practices related to conservation of resources and sustainability such as tillage, cultivation, cropping sequences (rotations), use of legumes, plant populations, row widths, practices used on set-aside, cover crops, and residue management.

It should be recognized that some pesticides can be very beneficial and contribute greatly to resource conservation, reduced inputs, and sustainability. Some new compounds can be very efficient to produce, transport, store, and use while decreasing the need for containment structures and container disposal. It should not be assumed that reduced

tillage (lo-till and no-till) require more herbicides at higher cost.

In dealing with water quality, pesticides might be classified as: (1) least likely to enter water supplies, (2) may enter water supplies but present little or no health risk, and (3) may enter water supplies and present health risk.

Additional emphasis on interdisciplinary research is needed to explore opportunities for taking advantage of allelopathy, insects, disease organisms, and other nonsynthetic pest control techniques for weed control. However, greatest success will likely come from complementary use of both chemical and nonchemical techniques. Similarly, those involved in "alternative agriculture" should not become polarized, but need to cooperate. While on-farm verification of research and demonstrations are desirable, extreme caution should be taken in moving away from traditional research and technology transfer systems that have been so very successful and beneficial. However, increased attention should be given to setting an agenda for well coordinated research. What are the major needs and opportunities for the agricultural community and society, and are they being adequately addressed? How efficient is the competitive grants system? Does it adequately encourage interdisciplinary teamwork? Expert systems need increased attention as a means of helping assure greater precision, efficiency, and sustainability for farmers.

IPM, Pesticide Impact Assessment, and Pesticide Applicator Training programs have all proven their value and need to be established on a more permanent basis. The present "temporary" status jeopardizes continuity.

Introduction

The NRC committee and Board on Agriculture staff are to be commended for a very timely report. The committee, composed primarily of members from academia, is to be commended for presenting a state-of-the-art review of U.S. agriculture, injecting thought provoking challenges, and including real life case studies of innovative farming operations. The report can serve many sectors as a foundation on which to build and amplify.

Weed control is a major consideration of farmers and a major reason for many inputs. And herbicides are the major class of pesticides being used. However, weed science did not appear to be well represented on the NRC committee. This did not preclude at least some modest attention to weed science in the report, and creates the opportunity for amplification. Similarly, representation of the agricultural industry sector seems rather modest, even though some industries are developing innovative new approaches.

Although government programs and agencies are frequently criticized, they have encouraged many very progressive practices contributing to resource conservation. And with a little fine tuning, there are tremendous opportunities for adoption of some of the proposed practices as they relate directly to programs developed by such agencies as the SCS and ASCS.

Far too often, low input sustainable agriculture is interpreted as nonchemical agriculture. And the term "alternative" may imply a completely new system. Unfortunately, there seems to be polarization into two groups, chemical and nonchemical. In real life, as indicated by the case studies, the vast majority of farmers use chemicals. However, most are interested in more judicious use of chemicals, conservation of resources, and sustainability. It should certainly not be assumed that all chemicals, synthetic or natural, are bad. And the goal should not be the simplistic banning of all chemicals. Rather, we need greater precision in selection and use of both chemicals and nonchemical practices in a judicious manner to assure conservation of resources and sustainability.

The report appears to emphasize some of the following issues. Rather than criticize the report, we will attempt to amplify on the issues based primarily on experience and observations in the Midwest.

Conserving Soil

Conservation compliance and other recent initiatives of the SCS and ASCS are encouraging giant strides in conserving soil. Many farmers have changed from the moldboard plow to chisel plows, field cultivators, or disks for primary tillage. An increasing number are leaving soybean stubble over winter and using little or no tillage in the spring for corn following soybeans.

The SCS seems to strongly promote terraces, contouring, and continuous no-till. In many areas, these practices have not been readily adopted. However, many farmers do appear to be more receptive to more modest changes such as systems that will leave vegetation or crop residue as cover to protect the soil for the majority of the year. They generally consider this lower cost and easier than using terraces.

Although continuous no-till has not gained wide acceptance, many farmers are using tillage rotations. For example, with a corn-soybean cropping sequence, they may use little or no tillage for corn following soybeans, but use modest tillage after corn in preparation for planting soybeans. However, systems for no-till soybeans after corn have been developed and are gaining acceptance.

Very successful systems have also been developed for no-till corn or soybean production after legumes such as alfalfa or clover. Double-cropping, such as soybeans following wheat, has also been well accepted and is often done no-till. Use of small grain crops for cover has been modest, but there is some increased interest in use as part of a no-till system. Research also suggests some potential for such legume and nonlegume cover crops to aid in weed control and allow reduced herbicide use.

One major misconception is that reduced and no-till systems require more herbicides and higher chemical costs. Recent research with corn no-till in soybean stubble and corn in clover sod indicate good success with no increase in herbicide inputs. And, the spray-plant-harvest system with no tillage or cultivation truly means low input while maintaining good yields.

Another dilemma is the notion by some that "alternative agriculture" means not using any herbicides. As vividly indicated by the case studies in the NRC report, modest use of herbicides can allow very practical and economical practices to reduce tillage and conserve soil. For the foreseeable future, the most logical approach for conservation tillage systems will likely be the use of both nonchemical and modest chemical control practices in a complementary manner.

Cooperation between the SCS, ASCS, and Extension appears good. Conservation compliance is being fairly well accepted by farmers, if kept practical. And the agencies are to be highly commended for tremendous progress with recent initiatives as directed by Congress and the Administration to conserve our precious soil resources.

Rotations

The NRC report seems to dwell repeatedly on the importance and benefits of rotations. There are implications of excessive monoculture. It may be somewhat difficult to avoid monoculture in some wheat producing areas, for example. And there is little alternative to monoculture for orange groves and apple orchards. However, much of the cornbelt might more properly be termed the "corn and soybean belt." There is some continuous corn, and soybeans sometimes follow soybeans. However, a corn-soybean cropping sequence is quite popular and offers many opportunities for higher yields, better insect control with less need for insecticides, tillage rotations, herbicide rotations, less opportunity for development of resistant weed species, and less opportunity for accelerated herbicide degradation that could mean decreased weed control and more herbicide.

One of the most overwhelmingly obvious opportunities for rotations that include the advantage of legumes has been essentially overlooked in the NRC report, but this is not uncommon. That opportunity is for legumes, and perhaps some nonlegumes, for land set aside from production.

The ASCS is to be highly commended for their administration of programs of considerable magnitude. They have done very well at keeping records, writing checks, and helping to subsidize farmers. However, there has been a major need for better vegetation management on land set aside from production for the long-term conservation reserve program (CRP) or short term set-aside. The ASCS guidelines indicate that weeds should be controlled and some spot checking is done.

The urgent need is for more guidance to help farmers select those plant species that can provide significant benefits very economically. Too often, set-aside acres have been weed patches with prolific weed seed production being added to the soil to require the increased use of herbicides for many years.

The ASCS does not appear to perceive their role as being responsible for research to develop good vegetation management systems. Neither do they seem very aggressive in recommending or requiring good vegetation management. The SCS and Extension have helped fill this deficiency to some extent. And some farmers have learned by experience. But much more emphasis is needed on good vegetation management on land set aside from production.

Set-aside land might be considered as part of a rotation and can very definitely benefit from use of legumes to provide weed control, add nitrogen, provide a protective soil cover, improve soil structure, and encourage wildlife. More research is needed to determine what plant species can best encourage natural predators while contributing to control of insects, weeds, pathogens, and nematodes. For filter strips, what plant species will tolerate certain herbicides, help degrade them, and reduce movement into surface and ground water?

The report has considerable information on the amount of nitrogen that can be added by various legumes, but appears to neglect opportunities to do so during the set-aside years. One chart in the report vividly indicates soybeans to be one of the most effective nitrogen-fixing legumes. Soybeans deserve consideration for set-aside. Farmers know how to control weeds in soybeans. Having soybeans on set-aside could provide a very convenient reserve for drought years. In good years, soybeans could be added to the soil of set-aside land and significantly reduce off-farm inputs for corn the following year.

The ASCS has been concerned that some farmers might be tempted to "moonlight requisition" soybeans on set-aside. Perhaps such temptations could be deterred by innovative techniques such as development of soybeans with a different color, use of long season varieties that would not mature, or simply spot checking for soybeans left standing. If farmers are honest enough to trade grain with "verbal contracts," surely they would require little regulation for soybeans on set-aside.

Conservation of Fossil Fuel

Very little attention is given in the report to the importance of conserving nonrenewable resources such as fossil fuel. On the contrary, increased use of cultivation appears to be advocated. The case studies suggest systems that would require more trips over the field, more fossil fuel, and perhaps increased equipment costs.

Rotary hoeing can provide very effective early weed control and can complement use of herbicides extremely well. Some row cultivation is also still used. But farmers have dramatically changed their production practices. They no longer check plant corn to allow cross-cultivation. Thus, it is difficult to control weeds in the row with a row cultivator. Band application of herbicides over the row and cultivating between the rows is one alternative to allow reduced herbicide inputs. However, as indicated frequently by the case study farmers, rain may sometimes prevent timely cultivation.

Nonchemical Weed Control

In addition to use of tillage, rotary hoeing, and row cultivation, there are a few other nonchemical control techniques to be considered. The report makes modest mention of some.

There are a few classic examples of the use of insects to control weeds. This may be occurring in the ecosystem more than we realize. However, relatively few scientists have the interdisciplinary training, interest, or encouragement for such research. Field observations and a few success stories suggest some potential for control of certain weed species with insects and the likelihood of some selectivity. However, incentives are needed to encourage such research.

Similarly, there are some success stories and classic examples of using disease organisms to control weeds. Within the weed science profession, the work of Dr. Roy Smith with the U.S. Department of Agriculture in Arkansas is well recognized. He has successfully developed a technique for controlling northern joint vetch in rice with a disease organism, and this has been commercialized. One of the challenges is to maintain favorable conditions for the disease organisms, and innovative research is in progress in the private sector to explore this. Opportunities exist, but again, additional incentives are needed to encourage additional research.

Allelopathy is mentioned in the report. Limited research is in progress to explore opportunities for taking advantage of naturally occurring chemicals from some plants to inhibit growth of weeds. Although there are a few weed scientists working in this area, more encouragement is needed. A modest amount of herbicide may be appropriate to manage the species providing the allelopathic effect. However, some very good scientists have been discouraged when proposals are not approved for funding because some reviewers do not approve of any herbicide use.

Some degree of weed control can be achieved by interference of crop plants with weeds. Interference might involve competition for nutrients, light, moisture, and also allelopathic as well as mulch effects. Farmers have increased plant populations and plant crops in narrower rows than previously. Such practices are common and have contributed significantly to nonchemical weed control. Farmers possibly could benefit from further research to develop a better understanding of such relationships.

Resource-Conserving Chemistry

Another area neglected in the report is the potential for some new chemicals to greatly contribute to resource conservation and environmental quality. For example, some sulfonylureas can be used at less than an ounce per acre. This can mean considerable conservation of resources for manufacture, transport, storage, and application. It can help save expenses for containment at storage sites and it can help solve container disposal problems.

In addition, some of this new chemistry is helping to fulfill needs for conservation tillage systems to encourage greater adoption and help assure success.

Cooperative Crop Reporting Service Surveys

In order to monitor change, information is needed on what practices farmers use. Such information is essential for planning and evaluating programs. The Cooperative Crop Reporting Service does a very commendable job. However, greater emphasis is needed on monitoring some practices such as tillage, cultivation, double cropping, management of set-aside, rotations, and pesticide use. Some increased thrust is apparently being planned for pesticide use. However, if that had been done two or three decades ago, we would now have a much better information base for addressing issues such as water quality.

Water Quality

The NRC report contains some data and discussion regarding agricultural chemicals and water quality. The data provides some examples of what pesticides are being found in ground water and surface water. It recognizes that the majority of pesticides being used are herbicides. However, suggestions for strategy to avoid water contamination are somewhat meager. The report suggests that opportunities already exist to reduce water contamination through modified agricultural practices such as increased use of legumes as a nitrogen source, adoption of IPM, and shifts in regional cropping patterns. This seems to be a rather simplistic view. Some soil scientists would question the supposition that nitrogen from legumes is much less subject to leaching than nitrogen from commercial fertilizer. To expect significant shifts in regional cropping patterns may not be very realistic. However, increased emphasis on IPM in a broad context is a very viable option.

Recent initiatives by the SCS suggest that their personnel may become more involved in helping farmers consider soil characteristics and pesticide characteristics when selecting pesticides. These initiatives probably were not far enough along for the NRC committee to review them, but they now deserve considerably more attention. The ASCS also appears to be "putting their toe" in the water issue and fortunately are seeking some guidance, at least in some states, but could benefit from some fine tuning in policy and guideline development at the national level.

As the report indicates, some insecticides are being found in water and insecticides are generally more toxic than most herbicides. However, the detection of herbicides appears to be relatively common. Greater involvement of weed scientists is needed to develop data, interpret the data, and design programs to alleviate water quality concerns. In part, what should laboratories be looking for, what should be done about what is found, and what alternatives exist or should be developed?

The U.S. Environmental Protection Agency appears to be developing much more stringent standards related to water quality as they consider registration of new pesticides. But what do we do about the pesticides that have been used for perhaps two or three decades, are still being used, and are sometimes detected in water? The answer seems relatively clear if we establish three categories: (1) what pesticides are not likely to get into water supplies; (2) what pesticides may get into water but are not of significant health concern; and (3) what pesticides may get into water and be of significant health concern? We can expect some pesticides to fall by the wayside by voluntary action of industry and some by regulation.

A major challenge is to provide the agricultural community with least risk alternatives in selecting pesticides and methods of use. As the NRC report indicates, IPM can play a major role in wise selection and use of both chemical and nonchemical methods in a complementary manner. More judicious use with greater precision and accuracy will be a key objective. Professional crop production consultants can play a major role, and this should be more adequately recognized by such agencies as ASCS.

Integrated Pest Management

The report presents some indication of the current status of IPM and presents a commendable positive view of the significant contributions IPM can make for "fine tuning" pest control. Visions and terminology need to be broadened to include more aspects of crop production than pests. And further expansion of the crop consultant network should be strongly encouraged.

The NRC report may be a little deficient in not more adequately describing some of the new technology and systems that have been developed to predict and monitor pest infestations. Such programs can aid greatly in adding the precision needed to avoid excessive use. Such technologies as optimum timing and use of adjuvants can improve efficacy and reduce inputs.

Many of the "young tigers" engaged in agriculture today already have computers and are eager for programs that will help them add precision, cut costs, increase net returns, and help assure sustainability from both a resource and economic viewpoint. The agriculture of the future should not be viewed as "returning to the way Grandpa did it," but rather using modern technology such as "Expert Systems" to provide the precision needed to use scientific advances wisely.

One of the most neglected areas by both farmers and in the report is use of programs to indicate optimum amount and size of equipment for a farming operation.

Research

The report indicated that "alternative farming methods have not been widely adopted" because "research on alternative agricultural systems is lacking." Much of the research conducted by the U.S. Department of Agriculture and at universities has been oriented not only toward increasing production and efficiency, but also toward conserving both physical and economic resources to concomitantly help assure sustainability.

It is true that emphasis in weed science, for example, has been placed on herbicides because that is where the perceived needs, interests, and funds have been. The relatively few weed scientists in a new discipline had little choice but to direct primary attention to "where the action was." However, some very imaginative, creative, and dedicated scientists at public supported institutions have addressed many other phases of weed control such as allelopathy.

Scientists have little choice but to orient research toward those areas where funding is available. Their state or institution may provide the majority of land, facilities, and some personnel, but whoever invests a modest amount can have the program directed to match their interests. Recognizing this bargain of getting perhaps $3 or $4 worth of research for $1 and also recognizing the expertise of agricultural scientists, some firms or agencies have lured agricultural scientists away from research directly related to production agriculture. For example, a weed scientist well trained to study soil-herbicide relationships might be conducting research on composting munitions for the defense department.

If society places a high priority on "alternative agriculture" and wants more research, the answer is quite simple, "crank funds into the system." Ready and waiting to "pick whatever plum is ripe," there are plenty of scientists willing to study "alternative agriculture."

In one major agricultural state, staff invested considerable time and effort in preparing about two dozen low input sustainable agriculture proposals for regional competitive grants. Essentially none were funded. Will they try again, or turn their attention elsewhere? As the name implies, the competitive grant system tends to encourage competition among scientists, rather than good interdisciplinary teamwork of the type needed to develop "alternative agriculture" systems.

The NRC report suggests the continued theme of competitive grants which could mean more isolated short term research projects with more reports filling library shelves. It would seem preferable to set an agenda of the needs and structure a program with interdisciplinary teams to address these needs. Perhaps rather than peering over piles of proposals, peers within a discipline should simply identify those scientists most logical to explore the opportunities and recruit them to contribute.

Weed control and use of herbicides seems to be a major concern for alternative agriculture. However, in the U.S. Department of Agriculture competitive grants program, weed science does not have its own individual category, and the success rate for weed science proposals is about 4%. Thus, weed scientists turn elsewhere for better odds.

Some administering low input sustainable agriculture programs appear to be skeptical of university scientists. As expressed in the NRC report, there appears to be a trend away from use of the traditional research and technology transfer system toward more on-farm trials with demonstrations not necessarily involving Extension. There is some suggestion that some low input sustainable agriculture "research" programs might end up as subsidies for nonchemical farmers and with data of questionable value. This does not preclude involvement of innovative farmers who are truly very interested and dedicated to change. But attempts to circumvent the traditional research and Extension system that has been so successful and reliance on testimonials rather than objective well conducted research could further polarize those who should be working as a team to help assure the sustainability of American agriculture.

Extension

The section of the report on research and extension is well done. It was apparently written by someone with a good understanding of the current status as well as the vision and courage to suggest changes. Extension has an outstanding record for helping farmers adopt new practices and for being a tremendous catalyst for bringing about appropriate change. Farmers have profound confidence in Extension to provide appropriate guidance based on objective research.

Extension is interested and ready to encourage adoption of alternative methods that are in the best interest of farmers and society. However, Extension has little choice but to give priority to those programs for which adequate resources are available. If Extension is to remain viable, the entire system needs bolstering of resources. Staff on special programs need more assurance of tenure and opportunities for advancement if there is to be continuity. Programs such as pesticide applicator training, pesticide impact assessment, and IPM need to be established on a more permanent basis.

Alternative Agriculture
Application to Potato Production

Gary A. Lee
Director, Idaho Agricultural Experiment Station
and
Joseph F. Guenther
Associate Professor
Department of Agricultural Economics and Rural Sociology
University of Idaho

SUMMARY

The potato industry is not subsidized by the federal government, yet a number of crop management practices recommended by the National Research Council (NRC) report are routinely used in the production of the crop. Despite the industry's use of integrated pest management practices, there are a number of potato pests that cannot be controlled by nonchemical means.

It is virtually impossible for the Idaho potato industry to adapt the NRC recommendation to rely solely on organic sources for nitrogen and other plant nutrients. Such impacts on other agricultural industries have not been considered in the report.

The NRC recommendation to alter grading standards to allow more pest-infected, lower quality products into the fresh market would exacerbate food safety problems. Such standards have been implemented to protect consumers.

Legislative mandates to adapt some of the NRC recommendations would severely impact the potato industry. Labor shortages and losses of capital invested in potato production, storage and processing would be immediate problems resulting in an unstable supply of potatoes for the nation's consumers.

REVIEW

The National Research Council (NRC) study entitled *Alternative Agriculture* leaves the reader with a vivid impression that all conventional agricultural production practices are environmentally unsound and directly contribute to pollution, and degradation of natural resources and consumer health problems. Further, the report implies that producers can only afford to use off-farm inputs because of government subsidies and ignores the quality and safety benefits of modern pest control practices. Recommendations have been made based on specific crops which when applied to the nation's agricultural industry as a whole could destroy our ability to produce safe and abundant food, feed, and fiber. The report advocates reduced pesticide and inorganic fertilizer use; however, close examination of the case studies indicates that more, not less, pesticides are used in some of the alternative agriculture system examples. In other cases, manure is recommended for replacement of off-farm sources of fertilizer, but the numbers of animals required to provide organic sources of plant nutrition makes the recommendation impractical.

Potato is an example of a perishable crop which is not subsidized by government programs. Yet, production of a potato crop which meets consumer demand requires substantial off-farm inputs and, for the most part, the crop must be stored under controlled conditions until consumed through fresh or processing markets. Potatoes are the most popular American vegetable and are grown on 1.2 million acres in 38 states (National Potato Council, 1989). The potato industry is vital to the economy of many states. The following discussion reflects only selected areas of potato production which are not compatible with the recommendations of the NRC report.

Crop Management

The statement, "many federal policies discourage adoption of alternative practices and systems by economically penalizing those who adapt rotations, apply certain soil conservation systems, or attempt to reduce pesticide applications" (page 10), cannot be implicit for all crops. Potatoes are a nonsubsidized commodity which virtually cannot be grown in monoculture, and yet the require extensive off-farm inputs of fertilizer to produce a crop which meets consumer demands for quality. In the arid west, potatoes are included in crop rotation systems that are five to seven years in length and most often include a legume crop.

Nutrient availability and regulation is paramount in producing a potato crop which meets industry standards and one that has a reasonable profit margin for the producer. Nitrogen is the most critical element, and available levels must be carefully managed throughout the growing season. Crop yield, specific gravity of tubers, and tuber maturation and size are significantly influenced by nutrient balance at the various stages of plant growth. Thus, a majority of producers in the Pacific Northwest rely on consultants to monitor nutrient levels in plant petioles (leaf tissue) and for fertilizer recommendations. Prescription application for fertilizer is provided on an "as needed" basis by injecting the correct dosage through irrigation systems.

The NRC report infers that off-farm sources of inorganic nitrogen fertilizer are undesirable and that only organic nitrogen sources (plant residue and animal manure) should be used for crop production. Potatoes grown in crop rotations that include a legume crop do benefit from the mineralized nitrogen source. Four (4) tons of legume biomass containing 2.5% nitrogen would be required to provide 200 pounds of nitrogen. Since the decomposing plant material releases approximately 50% of the nitrogen per year, 100 pounds of nitrogen would be available to the crop. Commercially grown potatoes commonly yield 15 to 20 tons per acre (300 to 400 hundred weight), which requires 150 to 200 pounds of available nitrogen per acre. It is clear that only a portion of the potato crop requirements can be met by the legume source of nitrogen in the first year following the legume rotation. Further mineralization of the legume biomass during subsequent years will provide markedly less nitrogen to potatoes grown in the latter stages of the crop rotation.

If livestock manure is substituted as a nitrogen source, as advocated in the report, the number of confined animals would have to be increased to an unrealistic level. For illustration, Idaho produces potatoes on 350,000 acres annually. A 1,000 pound dairy cow will produce approximately 150 pounds of nitrogen per year in manure. This is enough nitrogen for about one acre of potatoes, assuming that 75% of the nitrogen can be conserved during storage and application and that 50% of the nitrogen applied is available through mineralization to the crop the first year. Accordingly, 875,000 cows weighing 1,000 pounds would be needed to provide the nitrogen source for the state's potato crop. The 1989 Idaho Agricultural Statistics (Idaho State Department of Agriculture, 1989) reports a total of 168,000 dairy cows in Idaho in 1988, which is only 20% of the required number for potato fertilization. The example does not consider the impact on excess production of milk, cheese, and other dairy products, red meat production, or other sectors of the livestock industry, or the expense and logistics problems that would result from manure storage, transport, and application.

Extrapolation of a case study conclusion to the entire agriculture industry of a state or the nation is virtually impossible. The use of off-farm sources of plant nutrients is essential to maintain economic yields and quality of our potato crop. The nitrogen released by manure may not coincide with nitrogen demand by the crop during the growing season. The nitrate form of nitrogen is subject to leaching from the soil surface regardless of source, i.e., organic or inorganic. Research is continuing to develop management practices to reduce leaching losses and increase efficient use of nitrogen.

Pest Management

Potatoes, like many minor crops, will be significantly impacted by the Environmental Protection Agency regulations for reregistration of pesticide uses. Pesticide manufacturers cannot justify the investment to develop the supporting data needed to meet the expanding criteria to license a pesticide for minor crops like potatoes. The NRC report (page 13) concludes that there is a propensity to retain old pesticides at the exclusion of biological control, genetically engineered resistant crops, and integrated pest management (IPM). Nothing is mentioned about the fact that no natural enemies are known (and may not exist) for most disease organisms,insect pests, nematodes, or weed species. The reason a major pest is a pest of a crop can be attributed to the lack of natural enemies to suppress the organism's population. The loss of a broad base of pesticide chemistry will result in more frequent applications of the same compounds and likely hasten the pest resistance problems referred to in the NRC report.

Pests of potatoes are, for the most part, carefully managed. Sanitation practices, crop rotations, and pesticides are incorporated into IPM programs as a part of the conventional crop management system to disrupt pest cycles.

Bacteria, fungi, and virus pathogens commonly cause problems in the production of potatoes. The potato crop is vulnerable to disease attack from the time of planting through postharvest storage. *Fusarium* seed piece decay can be controlled by the systemic fungicides, thiobendazole and thiophanate-methyl. Nearly all potato seed planted in Idaho is treated with one of these two systemic products. Without pesticide protection the crop stand, vigor, and ultimate yield is jeopardized. Consumers should not be alarmed at the use of these pesticides since they are used as medication to control internal worms in livestock and thiobendazole is registered as a antihelmetic for humans. There is a vast difference in public perception between a fungicide and human medicine. Late blight (*Phytophthora infestans*) was the disease that caused the Irish Famine and still is a threat to potato crops grown in humid areas of the United States. Because there is an effective fungicide treatment (metalaxyl + chlorothalonil), quality potato crops can be grown consistently and reliably to meet market demands. Significant advances have been made in using genetic engineering technology to develop disease resistance in potatoes. Although not commercially available, new potato cultivars have been created which demonstrate resistance to potato virus X. The technological breakthrough will potentially reduce the need for pesticidal control of the green peach aphid (*Myzus persicae*) which transmits the virus from one potato plant to another during feeding.

Colorado potato beetle (*Leptinotarsa decemlineata*) and wireworm (*Limonius* sp. and *Ctenicera* sp.) can destroy entire potato crops. Insect monitoring is a common practice among growers, and pesticides are applied when infestations are determined to be at economic levels (Fisher et al., 1989). Alternative control practices are available for these insect pests, but they are not as effective as pesticides in protecting the crop from total destruction.

Nematodes (microscopic parasitic worms) pose a serious threat to a potato crop and can effectively render land unsuitable for potato production. The potato-rot nematode (*Dilylenchus destructor*) attacks potato tubers in storage and can destroy an entire harvested crop in a matter of weeks (Coepsell et al., 1989). Columbia root-knot nematode (*Meloedogyne chitwoodi*) and stubby-root nematode (*Trichodorus* spp.) causes tuber malformation and discoloration which is unacceptable to consumers. Despite the suggestion in the NRC report that consumers should accept lower quality food products, reality dictates that discolored and malformed potato tubers have no commercial value and must be fed to livestock as a waste by-product. Thus, potato producers carefully protect their land from nematode infestations. Once the pest is introduced, the only effective control is relatively expensive soil fumigation, because no alternative biological control measures are available.

Weeds constitute a major potato production problem causing direct yield losses, disrupted harvest, and may affect quality of harvested tubers. Undesirable plants may act as hosts for viral and other diseases and nematodes that attack potatoes. Herbicides are commonly used to kill weed seedlings prior to and after emergence to reduce the competitive effects on the growing crop (Burrill et al., 1989). Some control of annual weeds is achieved with mechanical tillage equipment, but herbicides provide more economical control when considering labor, machinery and fuel cost, and effectiveness of control. Perennial weeds can destroy a potato crop resulting from severe competition. In addition, quackgrass (*Agropyron repens*) underground shoots can grow through potato tubers rendering them unacceptable for the market. Unlike the examples presented in the NRC case study that states "the unique feature of the Fishers' cropping system is their view of Johnsongrass and other weeds: they no longer focus on trying to eliminate them but instead cultivate them as a source of feed for the livestock operation" (page 282), potato producers cannot allow their land to become overrun with weeds. The value of the commodity produced warrants the investment to protect the potato crop.

Quality

The NRC report states that "Federal grading standards, or standards adopted under federal marketing orders, often discourage alternative pest control practices for fruits and vegetables by imposing cosmetic and insect-part criteria that have little if any relation to nutritional quality" (page 12).

They also recommend that, "public information efforts should explain to consumers the relationship of appearance to food quality and safety" (page 19).

What is the current body of information that relates appearance to food quality and safety? Who knows? The Academy does not address this in the publication. The report leaves the impression that there are no quality and safety problems with unattractive fruits and vegetables grown without the benefits of modern pest control.

Contrary to the opinion of the Academy, federal grade standards do involve safety issues. For example, green potatoes are a defect in the federal fresh potato grade standards. When potatoes are mishandled and exposed to light for several days or longer, they produce a toxic glycoalkaloid, solanine, and take on a green color due to chlorophyll production. These potatoes taste bitter and may be poisonous. This is a toxicity problem from nature, not one of synthetic chemicals.

The NRC report also implies that federal grade standards and federal marketing orders are the reasons that consumers don't want to eat insect parts in their fruits and vegetables. How many people like to eat wormy apples? The Academy doesn't discuss the possibility, but maybe federal standards aren't imposed on consumers for nefarious reasons. Maybe they are designed to communicate consumer tastes and preferences to growers. Producers capable of providing products that meet designated standards are paid more because of demand. Those who fail to meet acceptable standards are often unable to sell their crop at any price.

The Academy also implies that insects in produce are not in themselves a quality problem. Even if American consumers did like to eat insects, there may be related quality problems. For example, nematodes, wireworms, and other insects can damage potato tubers. True, it is probably not harmful for people to eat potatoes that are infested with nematodes and wireworms as such (assuming no psychological damage to the squeamish). These pests, however, cause surface damage to the potato tubers that allow spoilage bacteria and decay fungi to enter the tuber. Rotten potatoes present a serious quality problem that can spread to an entire potato storage. The decay microorganisms and/or products of their growth (e.g., metabolites, enzymes, and toxins) can cause serious food quality and safety problems.

The authors say that "public information efforts" are needed. Not educational programs, just information efforts. Apparently they are not aware how difficult and expensive it can be to change consumer tastes and preferences. Private industry and commodity organizations spend billions of dollars on advertising to get consumers to buy Sunkist oranges, California raisins, Frito-Lay potato chips, Wisconsin cheese, Idaho potatoes, and many other food products. Their advertising and promotion efforts are accompanied by stringent quality control. In the extremely competitive market for the consumer food dollar, the Academy assumes that "public information efforts" will convince consumers to prefer ugly, but organic, fruits and vegetables that are of inferior quality, prone to accelerated spoilage, and may present real hazards to consumer health. They also expect that these efforts will be sufficient to get consumers to pay higher prices for the ugly product.

In the executive summary of the NRC report, it is stated that "research should be expanded on consumer attitudes toward paying slightly higher prices for foods with lower or no pesticide residues, even though such food may not meet contemporary standards for appearance" (page 23).

Expansion of consumer research is a fine idea. The communication channels between consumers and producers should be strengthened. The Academy statement, however, is biased against conventional agricultural production methods. By saying "lower or no pesticide residues" the Academy implies that there are harmful levels of residues in food produced under conventional methods. They apparently accept this, but provide no evidence that residues which currently may or may not exist in the food supply constitute a real threat to human health. Indeed, the organic product may be more hazardous to human health than conventionally produced foods. Dr. Bruce Ames of the University of California at Berkeley (Ames, 1989) says that plants attacked by pests develop their own natural pesticides and that we ingest about 10,000 times more natural pesticides than synthetic pesticides.

Labor and Capital

The NRC report advocates nonchemical means of controlling pests and often discusses some alternatives. One alternative is to substitute labor for chemicals. The problem is that there might not be enough labor available to get the job done.

Potatoes are produced in sparsely populated regions where the supply of labor is small. Even today, with high-tech mechanized harvest operations many school districts in Idaho close school for two weeks in the fall so that potato growers have sufficient labor to harvest their crops. Labor is also scarce during the growing season. Many Idaho potato growers have switched from labor-intensive handlines to center pivots because of the shortage of workers who are willing to move irrigation pipe.

If the availability of labor is a problem with conventional production methods, what would it be like if farmers were forced to adopt labor-intensive, organic methods?

Loss of agricultural chemicals could create tremendous shifts and losses in capital investment. Potato-sprout inhibiting chemicals are one example. Due to modern storage technology, which includes the use of sprout suppressants, the northern tier of fall potato states now produce 85% of the U.S. potato crop. If sprout inhibitors were no longer available, the length of the storage season would shorten and some potato production would shift from the north to the south where winter and spring crops can be grown. This would mean that many potato storages would no longer be used and the millions of dollars invested in the facilities would be lost.

Losses of storage facility investments would be just the tip of the iceberg. The Idaho potato industry is a billion dollar industry. How much of that industry would be lost if the length of the storage season declined? What would the processors do to meet their raw product needs? Would they leave? How many people would lose their livelihood? We don't have the answers to those questions, but the effect on the Idaho economy would likely be devastating.

A shift of potato production from the northern U.S. to the southern U.S. would also increase the total amount of pesticides used in the potato industry. The harsh winter climate in the northern states kills many potato pests that are controlled in southern states by chemicals.

Potato sprout inhibitors are used so that the potato industry can provide the type of potato products that consumers want. If potatoes are stored at low temperatures, they are less likely to sprout but they convert more starch to sugar. This starch-sugar conversion causes frozen french fries and potato chips to be too dark for the preferences of American and Japanese consumers.

Conclusions

The NRC study entitled *Alternative Agriculture* has increased the awareness of needs and problems facing the nation's agricultural industry. Without question, greater investment to research and develop new technologies is needed to provide solutions for water pollution, soil erosion, and to reduce production costs. Policy makers, however, must proceed with caution in attempting to address the problems with more restrictive regulations without providing viable solutions and alternatives.

Recommendations presented by NRC cannot be broadly applied to the nation's agricultural industry. It must be emphasized that conventional practices presently used, in many cases, include practices advocated in *Alternative Agriculture*. Further, many alternative practices cannot be effectively implemented without severe impact on the production of a crop.

Potato growers are using crop rotations, modern pest management, and effective crop management practices. The crop is not subsidized; yet production and storage requires large capital investments to provide consumers with quality products which they demand. Producers will quickly adapt new alternative practices which are proven to be of value and protect their ability to grow a marketable crop.

Literature Cited

Ames, B. M. 1989. Pesticides, risk, and applesauce. *Science* 244:756.

Burrill, L. C., et al. 1989. Potatoes. *1989 PNW Weed Control Handbook.* Oregon State University, Corvallis.

Coepsell, P. A., et al. 1989. Potatoes. *1989 PNW Weed Control Handbook.* Oregon State University, Corvallis.

Fisher, G., et al. 1989. Potatoes. *1989 PNW Weed Control Handbook.* Oregon State University, Corvallis.

Hermanson, R. E., J. A. Moore, and C. F. Engle. 1983. *How to Calculate Manure Application Rates in the Pacific Northwest.* Coop. Ext. Serv. Publication PNW0239, Washington State University, Pullman.

Idaho State Department of Agriculture. 1989. *1989 Idaho Agricultural Statistics.* Boise.

National Potato Council. 1989. *NPC Statistical Yearbook.* Englewood, Colorado.

Vitosh, M. L., H. L. Person, and E. D. Purkhiser. 1988. *Livestock Manure Management for Efficient Crop Production and Water Quality Preservation.* Coop. Ext. Serv. Bull. WQ12, Michigan State University, East Lansing.

A Response to the NRC Committee Report On Alternative Agriculture

Don C. Peters
Department of Entomology
Oklahoma State University
Stillwater

SUMMARY

The committee must be complimented for recognizing, "Plant breeding has produced many economically significant pest-resistant varieties of major cultivars and is particularly relevant to alternative agriculture." They also provided an excellent summary of integrated pest management (IPM). They did not acknowledge that insecticide applications may be a satisfactory and desirable alternative control tactic in some IPM programs. The committee did not address the fact that land costs are a major factor in many enterprises nor did they seek out case studies where agricultural chemicals are used in a prudent manner for profit and long range environmental stability. I believe civilization can thrive with intelligent brew masters as well as with only hunters and gatherers.

REVIEW

On this 20th observation of "Earth Day" it is interesting to contemplate the shift in emphasis from population control and the aversion of famine to pollution control and sustainable agriculture. In these last two decades we have been able to increase food production as rapidly as human populations have increased, but economics, limits of transportation, and political factors have continued to allow many to die of starvation.

Having recently visited Monticello, I am of the opinion that Thomas Jefferson knew more about the agriculture of 1790 than any one of the committee members who wrote *Alternative Agriculture* know about current agriculture as broadly defined in 1990. The point is that in two centuries the United States has evolved to a level where 3 million farmers provide the food and fiber for the nation plus being a major source of export goods and balance of payments. In Jefferson's day the vast majority of the population spent their daylight hours producing food and fiber for their own consumption. Agribusiness is a 20th century concept of increasing ramifications. The diversity and complexity of U.S. agriculture in 1990 exceeds an individual's comprehension of biological, economical, sociological, legal, and political facts and principles. The committee has certainly highlighted many major concerns, but may have overlooked some other important areas.

Charles Hess and H. Rouse Caffey begin their letter of transmittal of the 1989 Joint Council on Food and Agricultural Sciences, Report to Secretary of Agriculture, Clayton Yeutter by saying, "The U.S. agricultural system is unequaled in today's world in terms of the variety, quantity, quality, and safety of foods made available at reasonable prices to consumers. The effective continued production, marketing, processing, and distribution of the nation's food, agricultural, and forest abundance are of significant social, economic, and political importance." In Oklahoma we say, "If it ain't broke don't fix it." But they continue, "Yet complex challenges confront U.S. Agriculture—challenges of responding to competition in the global marketplace; ensuring a profitable, sustainable food and agricultural sector; safeguarding natural resources and the environment; ensuring good nutrition and a high-quality food supply; and revitalizing rural America." This may be compared to the *Alternative Agriculture* preface statement: "For the rest of this century, agricultural producers and policymakers will focus on three goals: (1) keeping U.S. farm exports competitive; (2) cutting production costs; and (3) reducing the environmental consequences of farming." The interaction of producers and policymakers should be considered since producers feel overregulated and under rewarded for their great effort and investment. The *Alternative Agriculture* preface continues, "Farmers have a history of adopting new systems. While much work remains to be done, the committee believes that farmers, researchers, and policy makers will perceive the benefits of the alternative systems described in this report and will work to make them tomorrow's conventions." The alternative systems described seem to represent a small selected portion of possible innovations and are skewed toward a reduction of chemical inputs (even though data in several tables tend towards higher yields with economically feasible increases in fertilizer or pesticide applications.

Having survived over three decades of buzz words, low input sustainable agriculture (LISA), strikes me as more political than innovative. Oklahoma farmers have never enjoyed unnecessary spending and have a genuine desire to pass the land on to their children and grandchildren. Some form of reward must be obvious before a new practice will be considered for adoption, but my response was probably sought on the basis of my entomological expertise rather than as a farm land owner.

Research and Science

The committee must be complimented for recognizing that, "Plant breeding has produced many economically significant pest-resistant varieties of major cultivars and is particularly relevant to alternative agriculture." Hopefully, state and federal research support funds will become more available to those of us directly involved in identification, characterization, and facilitation of incorporation of durable pest resistance in economically important plants. Support for focusing biotechnological advances in this area seems to be lagging.

I am grateful that the committee acknowledged the importance of genetic diversity (page 120). Having followed this area since serving on the National Research Council (NRC) (1972) Genetic Vulnerability of Major Field Crops Committee, I know that genetic diversity means many things to many people. Entomologists and probably the other "pest" groups need to do far more research focused on understanding the fundamental biochemical, physiological, and behavioral aspects involved in genetic diversity of both the host and pest involved.

The committee must also be complimented for the excellent summary of integrated pest management (IPM). They did seem to stop short of acknowledging that insecticide application may be a satisfactory and desirable alternative control tactic in some IPM programs. To my surprise, 5 of 7 studies (Table 4-7, containing summary data on the economic evaluation of IPM programs) reported pesticide applications increased with IPM. Those five studies all had positive yield and dollar value for unit of production increases. Policymakers and the public need a better understanding of how IPM research is fundamentally directed at nonchemical tactics such as plant resistance, but current IPM practice may or must include pesticide applications for most profitable agriculture production to continue.

I felt the committee was too sensitive to what might be called the "Movie Star Mania" about pesticide residues and allowed statements like, page 89: "In California alone, 22 different pesticides have been detected in groundwater as a result of normal agricultural practices." to be included without comment. They know that chemical detection has far exceeded biological response levels for over two decades. Also Table 2-7, "Confirmed Pesticide Detections . . . ," was taken from an EPA 1988 Interim Report which has this statement on page 1: "Many of the reported detections have not been confirmed, and some of the contamination is from unknown sources." They were misinformed that, page 121: "Because insecticides to control greenbugs were not used for the length of time and in a manner that produced resistant greenbugs, the chemical could be used later when an emergency arose." Ethyl parathion has been used in Oklahoma against greenbugs every year from 1949 through 1989 without producing parathion resistant races. Statements like "non-Hodgkin's lymphoma health risk increased three- to six-fold" without any baseline value can be very misleading (page 121). Again, page 126: "insecticides accounting for 30 percent, . . . of all agricultural use have been found to cause tumors in laboratory animals." They seem to assume there is no threshold response level, but, in the next paragraph, "Based on available data, pesticide residues in the average diet do not make a major contribution to the overall risk of cancer for humans (National Research Council, 1982; 1987)." I would hope policymakers would accept this latter message and adopt the "Prudent Man" concept from the area of fiscal management and thus charge the IPM technician to apply this principle to each pest in each unique environmental condition of crop production in each unique geographical area. Such an "as needed clause" in pesticide registration should allow practitioners to produce crops under varied pest conditions with the responsibility for remaining below pesticide residue levels in the marketed commodity resting with the grower/IPM practitioner or consultant. Let me relate an experience in Lincoln, Nebraska, 1970s sorghum pest management workshop. A bright young Texas scientist said that we needed a new group of specialists to integrate all the research information. He was followed on the program by the local TV farm news reporter who said, "Nebraska has over 50,000 such specialists. We call them farmers!" Responsible decisions depend upon reliable data.

The fact that "more than 440 insect and mite species are known to be resistant to some pesticides" should also encourage public support for IPM as well as pesticide management programs.

Another major entomological problem is honey bee losses to insecticide applications to flowering crops and the need for adequate pollination.

As a synthesis of my evaluation, *Alternative Agriculture* provides at least partial information needed by policymakers to be objective as to economic potential, sustainable, viable, and ecologically sound agriculture policy. The committee did not address the fact that land costs are a major factor in many enterprises nor did they seek out case studies where agricultural chemicals are used in a prudent manner for profit and long range environmental stability. I believe civilization can thrive with intelligent brew masters as well as with only hunters and gatherers.

Case Studies

Clark BreDahl cash-rents from his mother ($50 per acre with $66 being the county average) and his Linda teaches school full-time (page 266). This alternative may not be available to many farmers.

Spray Brothers sell adzuki beans yielding 20 to 25 bushels per acre for $42/bushel. How many more bushels would it take to cause a surplus and ruin the market?

"The (Coleman Natural Beef) beef cattle are inoculated with a three-way vaccine for the common diseases of brucellosis, blackleg, and malignant edema; they are also injected with ivermectin to eliminate scabies and lice. No medicines or growth hormones other than these materials are given prophylactically." (page 393) These are all prophylactic treatments!

Alternative Agriculture Seriously Flawed

Robert D. Sweet
Professor Emeritus, Vegetable Crops Department
Cornell University

SUMMARY

The National Research Council report on *Alternative Agriculture* has limited usefulness because it failed to adhere to the accepted standards of the science community for objectivity, accuracy, completeness, and validation of major assumptions and conclusions. Instead, the report is an advocacy document for "alternative agriculture" and, as such, suffers the typical deficiencies of that type material. Examples: It failed to examine critically the allegations that agriculture is economically vulnerable, has negative impacts on the environment, is producing unsafe foods, and is not using alternative systems because of government programs. The negative data reported were not critically examined to determine if the system, *per se*, or poor management was the cause.

REVIEW

The NRC report on *Alternative Agriculture* is intended to aid policy makers and farmers in choosing alternative production systems. These supposedly would materially lessen agriculture's alleged economic vulnerability, its negative impacts on the environment, and production of foods unsafe due to chemical residues. Unfortunately the report's usefulness has been severely compromised by the fact that although it came from the science community it failed to adhere to the accepted standards of science for objectivity, accuracy, completeness, and validation of major assumptions and conclusions. Instead the report is an advocacy document for alternative agriculture and as such suffers the typical deficiencies of that type of material. Four examples:

1. It fails to examine critically the validity of the charges levelled against conventional production practices and proceeds as if they were true.

2. It fails to validate a major concept of the report, i.e., current government programs are a principal barrier to the acceptance of alternative systems by many farmers.

3. It fails to inform the reader that some of the episodes and data presented as evidence unfavorable to pesticides have either been refuted entirely or seriously challenged by respected scientists.

4. It fails to evaluate the impact on the environment or the chemical content of the foods produced on the 11 example farms compared to those from equally well managed farms using conventional systems.

Because political decisions are at their best only when the decision makers are thoroughly and accurately informed, it is regrettable that a major input from the science community is so flawed that if decisions are based primarily on the report as written, they may be equally flawed.

It is important for readers to understand the basis for my negative judgments in the four areas listed above.

First, failure to examine critically the validity of the charges that the current systems are economically vulnerable, have negative impacts on the environment, and produce foods which are unsafe due to chemical residues.

Economics

Data in the report as well as numerous reports from Land Grant institutions agree that unmanageable debt loads were the direct cause of many bankruptcies in the 1980s. This was brought about when inflation rates and prices of both commodities and land fell precipitously. Then some farmers who had made major purchases of land and equipment with borrowed funds were unable to avoid bankruptcy. There is no evidence that purchases of annual inputs such as pesticides, fertilizers, etc. for conventional systems were a significant factor in bankruptcies.

Environment

The data on negative impacts on the environment of current production systems are nearly worthless as presented because they are not site specific. It is impossible to determine if the negative results were due to the system, per se, or to poor management. Some carefully done studies such as those by the Water Resources Institute at Cornell demonstrate that with good management, high input crops such as corn are being grown successfully by utilizing conventional production systems, on soils classed as vulnerable to leaching, with no significant impact on ground water quality from pesticides. Studies with fertilizers are not yet completed, however, it is clear nitrogen is a problem and occurs with both chemical and animal manure sources. Preliminary indications are that the dangers to ground water will be more easily managed for chemical sources than for animal manures.

Food Safety

This highly charged public issue was passed over with no data or analysis but with a statement that the issue was controversial. What a dis-service to the public and to agriculture! There are data from food safety studies as well as from regulatory agencies. All of this evidence shows our foods are safe. Compliance by producers with pesticide regulations regarding residues in foods is excellent, except for an occasional episode. In 1987 California conducted a massive study of pesticide residues involving more than 13,000 samples and in 85% of the samples found no detectable residues. About 14% had less than the legal tolerance and about 1% were above. However, these were not concentrated in a particular commodity or for a particular pesticide and thus did not pose significant health risk. Similar results were reported for special but less extensive studies in Michigan and Mississippi.

Second, government programs constitute a major barrier to the adoption of "alternative agriculture." Since Federal programs are multi-billion annual costs to the taxpayers, it is regrettable the report failed to test the validity of this charge. One easily applied test would be to compare production systems for both "program" and "non-program" crops. Potatoes, fruits and vegetables would make good examples. Another benefit would have been some insights into the impacts of relatively open markets on availability and prices of these foods as well as the economic health of the various segments of "non-program" agriculture.

Even cursory comparisons would show that purchased inputs per acre for non program crops are relatively high. Fertilizer rates exceed even those for corn, and the total tonnage of insecticides, fungicides, and nematicides applied on nonprogram crops exceeds that for corn, soybeans, and wheat combined. The consumer has abundant year-round supplies of high quality potatoes, fruits, and vegetables at affordable prices. As a group, producers of nonprogram crops are unquestionably excellent managers. Why have they not adopted alternative systems? Could it be they have some insights not shown by the writers of the report?

Third, some data and episodes presented as being negative to conventional systems have been either refuted or seriously challenged by the scientific community.

The insecticide, DDT, was cited as an example of how early agricultural pesticides caused severe damage to certain bird populations, and polluted oceans. How incorrect can writers be? About 50% of the tonnage of DDT manufactured annually was put directly into tidal flats, swamps, etc. for mosquito control. Run-off or leaching of DDT from agricultural fields just does not occur because it binds so tightly to soils. Only by erosion can DDT move from treated agricultural sites. It has never been reported in underground water due to agricultural applications.

The Kansas worker study claims that certain types of cancer were correlated with 2,4-D spraying for a period of years. Many expert toxicologist and reputable scientific groups have challenged this conclusion. The Kansas study relied on friends and relatives or seriously ill patients to provide data as to what materials, how many days per year, and for how many years the particular individual had sprayed 2,4-D. Unless an overwhelming causal relationship exists, these recollections cannot possibly provide proof of anything.

A much more reliable source of information is the records from large-scale custom or controlled applicators such as those from forest products companies, highway crews, utilities, etc. Some of these records are excellent and identify individuals, their actual spraying activities, products used, number of days per year, number of years, etc. They also show what protective gear was supposed to have been used. The Canadians are following the health status of hundreds of such workers for which they have reliable records over many years. To date there is not one bit of evidence that handling and spraying of 2,4-D has caused cancers of any type, or any other health problem.

Fourth, the report made no analysis as to the actual impact of the alternative systems on the environment or on food safety. Furthermore no comparisons were made with the impacts of conventional systems on the environment and food safety when the latter were implemented by managers with the above average ability possessed by the managers in the eleven examples.

The report wholeheartedly endorses integrated pest management (IPM), but fails to explain that it has been used successfully mostly with insecticides and to a limited extent with fungicides but with little or no change for herbicides or nematicides. Since herbicides comprise about 85% of all pesticide tonnage, should not this glaring circumstance have been given serious analysis? One can think of many possibilities: weeds and nematodes do not respond to current IPM strategies; scientists working with weeds and nematodes receive no funds because entomologists control the purse strings; programs already in place for weed and nematode control were utilizing state-of-the-art best-practice controls before IPM became popular.

Additional Comments

One example farm uses soil fumigation plus plastic extensively. Is this environmentally benign alternative practice?

It was gratifying to find frank statements about the California rice example and the difficulty after 18 years of trying in putting more than about 5% of their acreage under strict organic culture even though they receive a 50% premium in price for that product.

The Richmond, Virginia, example abandoned farming in favor of development in 1986. Why was this not indicated at least as a footnote? Since references from 1987 and 1988 were included, ample time for this notation was available.

Alternative Agriculture: Where Do Weed Scientists Fit In?

Philip Westra
Assistant Professor, Department of Plant Pathology and Weed Science
Colorado State University

SUMMARY

An analysis of the debate over North American farming systems shows a wide range of positions on the use of chemical inputs ranging from high level pesticide users to organic, zero pesticide users. These polar opposites are engaged in a fierce debate which encompasses politics, federal research dollars, consumer food quality issues, and environmental issues. As agriculture in North America becomes increasingly industrialized, new players (consumers, environmentalists, pro-organic groups) are increasingly demanding access to the inner circle of decision makers in American agriculture. Utilization of alternative agricultural systems for successful North American food production will require the involvement and contribution of weed scientists to develop weed management strategies. Several ways for weed scientists to contribute to the resolution of this debate are offered in this article.

REVIEW

The Alternative Agriculture Debate

Part of the rising groundswell of concern for alternative agriculture systems began with the recent LISA initiative in North America. LISA is an acronym for Low Input Sustainable Agriculture, a new phenomenon in American agriculture which has stirred considerable debate since its arrival on the stage of food and fiber production in America. In its strictest sense, agricultural sustainability is defined by the Wisconsin Rural Development Center as "those methods which use less commercial fertilizer, herbicides, and pesticides." Although LISA quickly captured the imagination and support of many who are philosophically opposed to agricultural pesticide use, LISA has received considerable criticism for shifting input emphases rather than lowering inputs. Other movements are closely allied with LISA concepts and include organic farming, regenerative agriculture, biodynamic farming, French-intensive methods, and CIRA (Controlled Input Responsible Agriculture). Although these movements may differ in their tolerance of chemical inputs, all are motivated by a desire to reduce or eliminate chemical inputs in farming systems. Perhaps a more inclusive umbrella for many of these positions is the current alternative agriculture position advocated by various groups who are concerned about the future of conventional North American agriculture.

A dialectical analysis of the current debate over North American farming systems shows a widely divergent range of positions on the use of chemical inputs. The prochemical proponents advocate the use of any and all synthetic fertilizers herbicides, and pesticides in a decision making environment which primarily emphasizes economic considerations. The pro-organic proponents advocate food and fiber production without the use of any chemical fertilizers, herbicides, or pesticides. Other farmers may practice farming methods that use varying degrees of both of these positions. These polar opposites are engaged in a fierce debate which encompasses politics, federal research dollars, consumer food quality issues, and environmental issues.

Herbicide use in the United States, based on pounds of active ingredient, increased sixfold from 1964 to 1986. Insecticide, fungicide, and use of other pesticides remained fairly constant over the same period. Herbicides represent by far the greatest volume of pesticides used in modern North American food and fiber production. This represents a disturbing trend in the eyes of some people, who would argue that we do not yet have adequate yardsticks to measure the environmental and health impacts of such quantities of herbicides entering the environment.

Additional considerations fuel the controversy over the use of chemicals in food and fiber production. By the year 2020, agricultural production worldwide will need to increase 90 to 140% to feed an anticipated world population of 10 to 11 billion.

Americans spend 10.4% of their personal consumption expenditures for food, in underdeveloped countries people spend 30 to 50% of their personal consumption expenditures for food. Americans enjoy access to the cheapest supply of food in the world if one analyzes "cheap" strictly in economic terms. If all pesticides were banned for North American agricultural systems, it is estimated that consumer food prices would rise by 45%. The burden of rising food costs would hit the poor and outcasts of society disproportionately more than the rest of society.

Estimates of current energy conversion ratios for conventional farming suggest that we extract only one unit of food energy for every 10 units of fossil energy input. Contemporary food and fiber production is based on relatively cheap fossil fuel, which has been used to replace high cost labor.

Modern agriculture has been dominated primarily by economic decisions, but increasingly is influenced by political decisions. People involved in agriculture are increasingly forced to consider environmental and food quality aspects of conventional food and fiber production systems. Decisions affecting agriculture used to be the exclusive domain of farmers, bankers, and members of the agricultural chemical industry. As agriculture in North America becomes increasingly industrialized, new players (consumers, environmentalists, pro-organic groups) are increasingly demanding access to the inner circle of decision makers in American agriculture. For some weed scientists, this pressure to consider new impacts (beyond economic impacts) of our weed control systems is unwelcome, and viewed as perhaps an intrusion on our operating turf. Whatever our immediate response may be, it is clear that weed scientists will be called on by society to increasingly monitor and address new impacts of the weed control technologies we develop. This will call for a new integration of our multifaceted discipline to deal with political, environmental, and ethical issues. The industrialization of agriculture not only put the stamp of science and technology on agriculture, but also transformed agriculture's connection with economic and political powers.

Several key points and accusations are made by prochemical proponents.

1. We enjoy access to the best quality, cheapest food supply the world or any civilization has ever seen; this is due in no small part to scientific and technological revolutions in food production, i.e., chemical fertilizers, pesticides, and new crop varieties.
2. Synthetic fertilizers and pesticides have minor health and environmental consequences compared to other aspects of our society such as smoking, industrial pollution, drugs, and alcoholism.
3. Our world is laden with many natural, organic toxins, many of which are far more toxic than synthetic pesticides.
4. Anti-pesticide people are not involved in a major way in food production, and do not understand the constraints to food production.
5. We will be noncompetitive with foreign food producers who have access to banned North American technology (i.e., imported foods have high pesticide residue levels).
6. There is an obvious hypocrisy to organic farming proponents who then make other life decisions which place the health of themselves or their children at risk.

Several key points and accusations are also made by pro-organic proponents.

1. Current farming practices poison the land, pollute streams, contaminate groundwater, and waste renewable resources.
2. Modern farmers have grown accustomed to chemical dependency in their farming practices and require an annual fix to keep their systems going.
3. Current farming systems do not make good long-term economic sense.
4. There are "substantial hidden costs" (i.e., health, environmental, food quality) to our current "cheap" system of North American food and fiber production.
5. Going organic requires several years to rid the system of the shock of chemical poisons and fertilizers.
6. The "earth" (i.e., Mother Earth) possesses self healing, regenerative powers which can be harnessed by organic farming methods.

Prochemical proponents tend to emphasize scientific research and tests which "prove" the efficacy of the modern farming system. Generally, they are quite well funded for their research activities. Pro-organic proponents tend to base their appeal on what I would term "religious type appeal" rather than on scientific evidence. They often are long on beliefs, but short on facts. Until the recent creation of the LISA competitive grants funding program, they have tended to be poorly funded, and still receive proportionately few of the total research dollars expended for North American agriculture.

Some might say of the pro-organic position, "Where's the beef?" Support for this position often is anecdotal, based on testimonials, and nonscientific in nature. Attendance at their meetings may be likened to a religious revival meeting, where the admission price for involvement is almost a spiritual requirement, i.e., "Have you got the spirit to be one with us in this organic movement?" Sometimes the pro-organic people are referred to as "mythkeepers" who guard some very real spiritual knowledge of an alternative form of agriculture that is essential to the heart and core of what American agriculture should be like.

Prochemical proponents may feel overwhelmed by the onslaught of publicity attacking their position, and often counter with a position that says, "Leave us alone, and we will provide you with a cheap, bountiful supply of food and fiber." Society increasingly is questioning the total cost, and the actual quality of this supply of food and fiber. Critics of the current system of agricultural production say, "Mainstream agricultural institutions not only have not been able to grasp the essence of sustainable agriculture, but do not even want to. . . . Mainstream agricultural institutions are too committed to the status quo to mount such a challenge." Although this may be a somewhat radical position, there is mounting sentiment that mainstream agricultural institutions have not risen to support sustainable agriculture in an appropriate fashion, and that the movement has its origins and motivation primarily from sources outside mainstream institutions.

For weed scientists, the crucial question is, "Do we want to be part of the solution to the current debate about alternative agriculture, or do we want to be part of the problem?" How do we remain part of the problem? By refusing to examine how we think about the science of weed control. When we allow our presuppositions and biases to color our response to weed science challenges, we affect our ability to conduct alternative agriculture research.

Those of us that are weed scientists need to consider the following two scenarios. Suppose for the sake of argument that society gives us a mandate to produce weed control strategies utilizing all existing and new herbicides currently available in the arsenal of weed control tools. If this makes us feel comfortable and self congratulatory on our past efforts as weed scientists, we need to look at scenario two that society presents us. Now suppose that society gives us a mandate to produce weed control strategies that use no herbicides or synthetic chemicals. If this mandate makes our blood pressure rise, then perhaps we need to ask ourselves if we are "weed" scientists, or are we "chemical, herbicide" scientists. What intrinsic difference does it make to us, if we are objective and unbiased in our scientific, research endeavors, if we can, or cannot use herbicides?

Part of the problem in American agriculture has been the shift in paradigms which rule our activities. For several decades, the ruling paradigm was the desire to provide food sufficiency for our country, and perhaps to help feed other people in the world. Recently, the paradigm of sustainability as influenced by land, energy, groundwater, and ecosystem conservation has come to influence the value system and discussion about American agriculture. Even more recent has been the arrival of the paradigm of rural community, along with discussions of the value of small family farms, the erosion of small rural communities in North America, and the way of rural American life has come to influence the debate over American agriculture.

Pro-organic proponents need to consider the following scenario. If society tells us to produce food without the use of any synthetic pesticides or fertilizer, and we pat ourselves on the back and rejoice that society has finally "seen the light", then consider scenario two. If society tells us to produce food with reduced or limited use of synthetic pesticides and fertilizers, do we see this as a threat or compromise to our position? Who then is guilty of allowing *a priori* presuppositions to rule the ability to discern what are appropriate activities to engage in to produce the food and fiber needed by our society and the world?

One message seems to be coming through loud and clear today. Society is saying "read my lips; use less fertilizer and pesticides." Part of the dilemma is that our society expects "microwave solutions" to every problems. It is my conviction that if alternative agriculture is to be widely adopted, there will be no microwave solutions to support it. Alternative agriculture research will require well funded, well planned, well executed long term research (5 to 10 years minimum) to provide the reliable data base to support alternative agriculture concepts in agricultural productions. What alternative agriculture proponents fail to realize is that once guns and bullets were invented, swords became irrelevant. Although fertilizer and pesticide use can and will decrease in North America, the cultural unfolding of these technologies in the hands of North American farmers will preclude a total return the bucolic, idyllic ways of farming of the 1930s and 1940s in North America.

No-till prochemical farmers may be able to achieve excellent weed control with a pre-emergence soil applied and a single postemergence herbicide strategy. An organic farmer may have to make five to seven mechanical tillage passes over a field in the same time frame to achieve comparable control. What will be the economic costs of such organic strategies? What will be the environmental impacts of additional tractors tilling weeds across North America? What will the effects be on carbon dioxide levels in the atmosphere, soil erosion, and soil compaction problems? Such issues will require an environmental balance sheet that will apply to the pro-organic strategy as well as the prochemical strategy. To do less will be to unleash the thoughtless pogroms of thoughtless bureaucratic decisions on a system that result in more harm than benefits. Such issues will require careful thought, research and investigation by all parties involved in the debate.

We need to ask if the prochemical and pro-organic proponents approach weed control from radically different positions, or if there are common areas of overlap and congruence where meaningful cooperative research and dialogue can occur. I believe there are issues involving economics, food distribution (so that all people, including the poor and outcast of our society can eat), justice (so that all who want to eat can afford an adequate supply of good quality food), and environmental factors. Would we all not like to pass on to our children an agricultural production system as good as, or better than the one we inherited from our ancestors?

A frustrating problem faced by weed scientists (and other scientists) is that many people in our society are scientifically illiterate; they make decisions based on emotions rather than on facts. People rarely ask, "What can science do for me?" They are more inclined to ask, "What is science doing to me?" This subtle distinction is critical to the current mistrust of weed scientists and our ability to provide clean, safe systems of weed control.

With the expected peace dividend after the recent thaw in East-West relations, are we weed scientists being called to help beat the swords of our cultures into plowshares to feed the world? Should we look at alternative agriculture as an obstacle to advances in our science, or as an opportunity to help numerous disenfranchised farmers on our globe? Should we help head the move to rediscover plants as a source of nourishment for our bodies, our families, our communities, and our country, or are we going to assist the move to view plants as biochemical factories to be manipulated and altered as powerful poker chips in a growing international poker game of economics and politics? We will need to work to change the current system of rewards for scientist who devote major portions of their careers to long-term alternative agricultural research.

There are specific ways in which weed science can fit into alternative agriculture projects.

1. We can be involved in meaningful dialogue with all players in the current agricultural systems debate.

2. We can lend the power of our scientific, logic-oriented minds to alternative agriculture weed control research. Pro-organic proponents need us to help design and conduct sustainable agriculture research.

3. We can increase our involvement in multidisciplinary, systems research that deals with multifaceted research topics.

4. We need to help lobby for additional state and federal dollars to fund long-term, integrated, alternative weed control research topics.

5. We need to help educate society and our children on the proper role of science in our world.

6. We can provide leadership in discovering innovative new ways to best manage weeds in alternative farming systems.

All we ask of modern weed scientists is that you spend 10% of your time meaningfully involved in alternative agriculture weed research to help resolve the debate about alternative agriculture weed control strategies.

Representative HAMILTON [resumes the Chair]. Thank you very much, Mr. Miller. Now we will turn to Mr. John Pesek who will speak on behalf of the Board on Agriculture.

STATEMENT OF JOHN PESEK, PH.D., HEAD OF THE DEPARTMENT OF AGRONOMY, IOWA STATE UNIVERSITY, AND CHAIR, BOARD ON AGRICULTURE, NATIONAL ACADEMY OF SCIENCES STUDY COMMITTEE ON ALTERNATIVE AGRICULTURE, ACCOMPANIED BY CHARLES BENBROOK, PH.D., EXECUTIVE DIRECTOR, BOARD ON AGRICULTURE, NATIONAL ACADEMY OF SCIENCES; AND ROBERT GOODMAN, PH.D., CALGENE, INC., AND MEMBER, BOARD ON AGRICULTURE, NATIONAL ACADEMY OF SCIENCES

Mr. PESEK. Mr. Chairman, we are pleased to have an opportunity to appear before the committee this morning to discuss the Council for Agricultural Science and Technology review of the 1989 National Academy of Sciences report on Alternative Agriculture.

This report has received a great deal of attention. The report is in its second printing and almost 40,000 copies have been distributed.

The report has stimulated, throughout the agricultural community, a far-reaching, generally constructive debate. And I think this is one of the main purposes for which the report was prepared. It is also receiving growing attention around the world. I have just had a visit with representatives of the Soviet National Academy of Agricultural Sciences who are very enthusiastic about using the report in their program. I am told there are plans for a Russian translation of the report and also that there are being translations made into Italian, Japanese, and possibly French.

Alternative Agriculture has been both unjustifiably praised and unfairly criticized. The collection of reviews of Alternative Agriculture compiled by the Council for Agricultural Science and Technology reflects the full range of comments and criticisms that have surfaced since the report's release. We are delighted to have this opportunity to respond to the major points which have been placed into the record.

The first point is the issue of definition. Our committee did, indeed, define alternative agriculture. Briefly, it says that it systematically pursues a more thorough incorporation of natural processes, reduction in the use of off-farm inputs, creative and productive use of the biological and genetic potential of plant and animal life, improvement in the match between cropping systems and the productive potential of the land, and profitable and efficient resource utilization with emphasis on improved farm management, conservation of soil, and other environmental dimensions.

Conventional agriculture is the predominant farming practices, methods, and systems of the region. We in hindsight wish we had defined it better. The problem with conventional agriculture is that it varies from one crop to another and from one site to the other. For example, the conventional agriculture of corn production in Iowa is quite different than the conventional corn production in North Carolina. And 15 years ago conventional agriculture production of corn in Iowa would have called for the moldboard plowing of land. Today we cannot say that this is any longer a conventional practice for production of corn in our State.

The second point to which we respond is the viability of alternative agriculture. We believe that there are elements of alternative agriculture which are viable and which, as has been pointed out by Mr. Miller, are indeed useful and utilized. We feel that in the long run we have to look at alternative methods, especially as the price of energy increases, society places a higher premium on environmental matters and food safety, new technologies emerge from all fields of biology and chemistry, and government policies tend to change and, in our words, level the playing field.

Some alternative practices, for example, in the grain production system involving legumes and livestock in the Corn Belt have been well worked out. Others have a lot of work to be done, and this was alluded to in our report and by Mr. Miller.

The third point is the key role of management in alternative farming. Most conventional farming systems have become very specialized and there has developed in the agricultural industry a very strong support base of information for these systems. On the other hand, at the moment, practitioners of alternative agriculture generally must develop and apply even more diverse sets of skills. Alternative agriculture is more complex in terms of management because the addition of each additional crop commodity and each additional animal species requires different types and more diffuse skills and, therefore, better management to utilize these skills effectively.

The fourth point is the fact that we were criticized in many cases that we have not recognized the traditional strengths of U.S. agriculture. From the report I quote:

> In the 1930's, crop yields in the United States, England, India, and Argentina were essentially the same. Since that time, researchers, scientists, and a host of Federal policies have helped U.S. farmers dramatically increase yields of corn, wheat, soybeans, cotton, and most other major commodities. Today, fewer farmers feed more people than ever before. This success, however, has not come without costs.

This is not saying that our agriculture has not been successful. We, indeed, give credit for the highly productive agriculture, as was given by Senator Symms in his opening statement.

We also indicate that during the last four decades, agricultural research at the land-grant universities and the USDA has been intensive and very productive. In other words, we are not turning against the present structure for doing agricultural research and extension.

For this reason, two of the central research recommendations have been the expansion of systems-based research, and in it we call for a $40 million additional competitive grants program focused on alternative agriculture, a nationwide network of applied, onfarm research, and demonstration projects which flow along the low-input sustainable agriculture procedure of LISA,-which is already in the statutes.

One of the questions or concerns raised by CAST in its criticism of our report was that it becomes extremely difficult to establish cause and effect relationships when we do systems research, and that it is difficult to do this. I guess my personal view is that we should not pull away from solving and working on problems that are difficult because they are difficult and hard to work out. I think this should be even more of a challenge to the agricultural science community.

The final point is a return to old-time agriculture. Our report does not propose to go back to horses and to Fords or tractors, or even before that time. We feel that many critics have a hard time understanding how persons who farm with rotations and utilize manure effectively can also utilize modern machinery, crop and animal varieties developed with advanced tools of modern genetics, and appropriate levels and formulations of fertilizers, pesticides, and other inputs. They can do this, and they have been doing this. We are not going back to old-time agriculture.

The other concern about that is that if we do this, that we would infringe on our ability to produce. We do not believe that there will be major reductions in production. In fact, we believe that the productivity of U.S. agriculture will continue to increase. We do recognize, however, that we have had an exploitive agriculture in the United States for many, many years. In most areas we have lost at least a third and often one-half or more of the organic matter content originally present when the land was first farmed. To date the loss of native fertility has been more than overcome in terms of crop yields by the addition to the soil of commercial fertilizers, crop residues, and other wastes.

In the long run, farmers will need to move toward alternative systems that actually build up the inherent productive potential of our soils to protect the purity of water supplies and other aspects of our environment.

Mr. Chairman, we would be delighted to respond to any further questions you might have and, if needed, provide for the record additional responses, of a technical nature, to the CAST report. And we also thank you for having this opportunity this morning.

[The joint prepared statement of Messrs. Pesek and Goodman follows:]

JOINT PREPARED STATEMENT OF JOHN PESEK AND ROBERT GOODMAN

Criticisms and Commentaries on the
1989 NAS Report
Alternative Agriculture

Mr. Chairman, we are pleased to have an opportunity to appear before the committee this morning to discuss the Council for Agriculture Science and Technology review of the 1989 National Academy of Sciences report Alternative Agriculture. I am John Pesek, Head of the Department of Agronomy at Iowa State University, and Chair of the seventeen member committee which wrote Alternative Agriculture. I am accompanied today by another member of the study committee, Dr. Robert Goodman, who is also a current member of the Board on Agriculture, the unit of the National Research Council which convened the alternative agriculture committee. Dr. Charles Benbrook, the Executive Director of the Board, is also here this morning.

Our report Alternative Agriculture has received a great deal of attention. More than 35 major daily papers ran lengthy front page stories on the report the day following its release. We are aware of six stories on major network news programs based on the report, and there is extensive, ongoing coverage in the agricultural trade press and professional journals. The report is in its second printing, and has sold nearly 40,000 copies.

But more important, the report has stimulated throughout the agricultural community a far-reaching, generally constructive debate. I might note, Mr. Chairman, that it is also receiving growing attention around the world. I have just had a visit with representatives of the Soviet National Academy of Agricultural Sciences who are very enthusiastic about using the report as the Soviet Union restructures its agriculture. Earlier, I had delivered several copies of the report to individual scientists I met on a previous trip to the USSR and to the Soviet Academy. I am told there are plans for a Russian translation of the report. It is also being translated into Italian, Japanese, and possibly French. Agricultural scientists and resource managers in Central and South America are using the report extensively as they move forward with efforts to develop more sustainable farming and agro-forestry systems in the critical transition zones between already cleared and settled lands and virgin tropical rain forests.

Alternative Agriculture has been both unjustifiably praised and unfairly criticized. It is a long and complex report, and requires considerable time and effort to digest fully. Unfortunately many people who have commented on the report--both favorably and critically--have not had time or the inclination to read it carefully, and have not fully understood what the report says. In addition, much concern and criticism has been focused more on what others have said about the report, rather than on the content of the report itself.

The tenor of the initial press coverage of the report was, in particular, a source of real concern throughout the agricultural community. Many stories and editorials inappropriately interpreted the report as concluding that American agriculture could sustain current levels of production and profitability with little or no use of agrichemicals. The report reaches no such conclusion, although it does state clearly that a range of alternative practices have the potential to reduce pest pressures markedly, and hence lessen reliance on pesticides as the principle means of crop protection.

The collection of reviews of Alternative Agriculture compiled by the Council for Agricultural Sciences and Technology (CAST) reflects the full range of comments and criticisms that have surfaced since the report's release. We are delighted to have this opportunity to respond to the major points raised in the CAST review, and wish to thank the Joint Economic Committee for contributing to what promises to be a lively, ongoing dialogue. This is indeed a time of heightened interest about these issues as the Congress works toward completion of the 1990 farm bill.

An Issue of Definition?

The CAST review states that Alternative Agriculture offers no definition of conventional agriculture, and hence there is no basis to make a scientific comparison of alternative and conventional agricultural practices, methods, or systems. Reviewers also highlight the fact that many different combinations of practices can be found on farms around the country, a point emphasized repeatedly in Alternative Agriculture.

We agree that it is a complex task to compare the performance of different agricultural systems, because so many factors must be taken into account. Moreover, we agree with several CAST reviewers, and we had stated clearly in our report, that alternative or conventional agriculture is not one distinct set of practices that comprise a unique system. Rather, conventional and alternative agriculture can be thought of as representing two points on a spectrum of practices, that arise from and reflect different approaches to management. For these reasons, it remains difficult, and often controversial to define conventional, alternative, sustainable, low-input, or organic agriculture. In hindsight, we recognize that it would have been valuable for many readers to have explained in more detail the distinctions among these various terms.

Let us take this opportunity to clarify for the record what we mean by conventional, alternative, and sustainable agriculture:

Sustainable agriculture is the production of food and fiber using a system that increases the inherent productive capacity of natural and biological resources in step with demand, while earning adequate profits for farmers, providing consumers wholesome, safe food, and minimizing adverse impacts on the environment.

Alternative agriculture is defined in Alternative Agriculture, and in the agricultural research title recently passed by the House and Senate Agriculture Committees, as any system of food or fiber production that systematically pursues the following goals:

- More thorough incorporation of natural processes such as nutrient cycles, nitrogen fixation, and pest-predator relationships into the agricultural production processes;
- Reduction in the use of off-farm inputs with the greatest potential to harm the environment or the health of farmers and consumers;
- Creative and productive use of the biological and

genetic potential of plant and animal species;

- Improvement in the match between cropping patterns and the productive potential and physical limitations of agricultural lands; and
- Profitable and efficient production with emphasis on improved farm management and conservation of soil, water, energy, and biological resources.

Conventional agriculture is the predominant farming practices, methods, and systems in a region. Clearly, conventional agriculture is not inherently bad or good, and will vary over time, and according to soil, climatic, and other environmental factors. Indeed, many conventional practices and methods will continue to play integral roles in the farming systems of the future, and are likely to prove sustainable when applied or utilized appropriately in systems that are otherwise well-designed in light of local soil and climatic conditions.

The CAST review raises a more serious definitional issue. It states: "Alternative agriculture relies on various techniques that were innovative when first introduced and which became common practices when adapted as part of conventional agriculture (e.g. crop rotation, conservation tillage, and integrated pest management [IPM]). Hence, delineation between alternative and conventional agriculture becomes indistinct, and the difference becomes one of philosophy."

Alternative Agriculture makes it very clear that there is more to the difference between alternative and conventional agriculture than philosophical orientation. The principle differences are highlighted in the definition quoted above. Alternative agricultural systems, in contrast to most conventional systems, rest upon the sophisticated management of biological and ecological cycles, forces, and interactions that lie at the heart of all farming operations.

Farming is, after all, an inherently biological process. Farmers who practice alternative agriculture are striving through management and the careful selection of agronomic and pest control practices to turn biological processes and interactions into assets rather than liabilities. Alternative agriculture relies upon an ecological approach to evaluate both the near-term and long-run consequences of farm management decisions so that the overall performance of a farming system can be more thoroughly understood and made more assuredly sustainable. To quote the report, alternative agriculture strives to "sustain and enhance rather than reduce and simplify biological interactions upon which production systems depend."

The degree of concern and attention to the long-term sustainability and performance of farming systems is central to the distinction between alternative and conventional agriculture. Farmers who have pioneered alternative agriculture systems tend to evaluate farm profitability over at least a few multiyear rotational cycles They are inclined to ask questions about the impact of current production practices on the longer-term sustainability and profitability of production practices measured in terms of human health and impacts on wildlife, from the perspective of food safety, and relating to natural resource and environmental quality. Such a long-run view will be needed for agriculture to respond to society's growing concern about the environment, yet a farmer's time horizon is, as a practical matter, becoming progressively shorter, collapsed by the need to assure economic survival, comply with government program rules, and meet community norms and expectations.

Farmers utilizing conventional systems share these same concerns, but tend to evaluate the performance of a farming system more narrowly in terms of per acre yields and profits in a given year. Also, they tend not to consider such a wide range of off-farm consequences or alternative cropping patterns, agronomic practices, and technologies in the design of farming systems. A practitioner of alternative agriculture would readily consider a change in crop rotation patterns on a given field to bring a particular pest under control, or to lessen reliance on a purchased input that is becoming more expensive. A conventional producer would tend to stick with the same cropping pattern, and seek some other solution or a new production input to solve problems that arise.

Viability of Alternative Agriculture

The CAST review states that "Alternative agriculture is viable in some situations, under certain economic conditions, at specific locations, under appropriate management expertise, and with a receptive market." This assertion misses the point. Again, quoting the report, " Alternative agriculture is not a single system of farming practices. It includes a spectrum of farming systems, ranging from organic systems that attempt to use no purchased synthetic chemical inputs, to those involving the prudent use of pesticides or antibiotics to control specific pests or diseases...Successful alternative farmers do what all good managers do--they apply management skills and information to reduce costs, improve efficiency, and maintain production levels."

Geographical differences, market conditions, the level of management skill, and farm policy are among the many factors that will affect the success of each farmer as he or she decides upon and manages specific cropping patterns, enterprises, tillage systems, pest control programs, and marketing plans in a given year. Regardless of the outcome of these decisions, all farms will benefit from a more systematic consideration of biological and ecological opportunities to improve the performance of their farming activities.

The success of any one farm in using alternative production practices in a given area and with a particular set of crop and livestock enterprises begs the question whether other farms in the area, or elsewhere but with similar soils and climatic conditions might also be successful in applying alternative systems. Indeed, one the principle conclusions of Alternative Agriculture is that virtually all farms will, over time, benefit from a continuing and probing assessment of biological and ecological performance, with an eye toward identifying new ways to avoid pest pressures, conserve soil and water resources, and make more efficient use of critical inputs like fertilizer and animal feeds. The economic value of such an assessment is likely to increase, particularly in the long-run, if and as:

- The price of energy-intensive inputs increases.
- Society places a higher premium on environmental protection and food safety.
- New technologies emerge, providing new opportunities to utilize genetics and biology to sustain high levels of production
- Government policies change to more nearly "level the playing field" as farmers consider the economic prospects of different management decisions.

Clearly then, alternative agriculture is relevant and applicable to all farmers. It is true, as several commentators have pointed out, that the science and practice of alternative agriculture is unevenly developed. For some crops in certain regions of the country, much is known about the scientific foundation of profitable, effective alternative agricultural systems that achieve, or approach many of the goals in the definition reported above.

Corn-soybean-small grain-meadow systems in the midwest are a good example. Many farmers have gained valuable experience with such systems. In conjunction with researchers, they are making rapid progress in delineating the specific considerations that play a central role in explaining farming system performance. In certain regions for some crops many of the practices integral to alternative agriculture are rapidly becoming conventional.

In other regions, and for some crops, our base of knowledge about the biology and ecology of farming systems is too poorly developed to evaluate critically the performance of conventional systems, let alone design effective alternatives. For this reason, some critics discount the importance or relevance of alternative agriculture, in effect asserting that if proven alternatives can not now solve all problems in all places, the promise of alternative agriculture should not be taken seriously.

Other critics follow a different line of argument, a line evident in several of the CAST reviews. They point out, correctly in most cases, that an alternative practice or crop rotation that works on a particular farm (like any of those featured in the Alternative Agriculture case studies) will probably not work as well or as consistently on a nearby farm with a different soil type, or where spring temperatures are cooler, or on a farm without livestock or lacking a given piece of equipment.

Economists are inclined to criticize the report for either failing to fully consider the macro-economic consequences of micro-level change, or the farm-level consequences of macro-policy or economic change. They also challenge recommendations calling for change in practices, programs or research priorities in the absence of thorough and compelling data and analysis demonstrating that everyone will be better off. We still lack the scientific bases to make such economic estimates, and will remain constrained by the limitations of contemporary scientific and economic knowledge until we do something to relax them. (See the research recommendations in Alternative Agriculture).

Standing alone, each of these cautions and caveats have merit, as do several others reflecting the uncertain, dynamic world in which we live. We were well aware of these concerns as we developed the report. Accordingly, we tried to stress throughout Alternative Agriculture that the development and application of alternative systems should proceed methodically and gradually.

Moreover, the report strongly emphasizes that alternative agriculture will not be easy nor without costs and disappointments. Nonetheless, the report conveys a hopeful message that rests in no small part upon the resourcefulness and common sense of the American farmer. The most important conclusion in Alternative Agriculture is that farmers, when armed with facts and new technology, should be able markedly--indeed often dramatically--to improve the economic and environmental performance of their operations.

Solutions to agriculture's contemporary problems will arise from more in-depth knowledge of the biology and ecology of farming systems, coupled with more precise management of agronomic and pest control practices. Novel solutions will evolve from a systems-based understanding of the functioning of a farm, and will remain elusive until our superior research capabilities in the sciences basic to agriculture are better funded (see the 1989 NAS-NRC report Investing in Research which calls for a $500 million increase in USDA's competitive grants program, and then matched with a serious effort to apply the results of scientific research to develop improved farming systems such as those called for in Alternative Agriculture.

The research agenda called for in Alternative Agriculture must focus on understanding the inherently interactive and complex nature of a farm enterprise. Greater research effort must also be matched and leveraged through the efforts of all public institutions that can help creatively apply the results of scientific research in the evaluation and design of farming systems. Attention must also be directed toward the reform of agricultural, regulatory, and marketing policies which stand in the way of innovation on the farm.

Key Role of Management

Alternative Agriculture stresses the critical importance of farm management skills in improving the performance of farming systems. Several CAST reviewers correctly note that solid management skills are equally vital for success on farms utilizing conventional production practices. A key distinction, however, needs to be emphasized.

Most conventional farming systems have become very specialized. In such systems, farmers exercise management discretion over the selection of tillage and planting systems, the selection of plant varieties; levels, sources, rates, and timing of application of plant nutrients purchased off the farm; and crop protection methods, typically herbicides for weeds, insecticides for insects, and fungicides for plant diseases. Even specialized, single crop cropping systems, which include vineyards and orchards, are very complex, and confront farmers with unique difficulties and many critical choices each season.

A practitioner of alternative agriculture, on the other hand, must generally develop and apply an even more diverse set of skills.

Many of the most critical management decisions in alternative systems occur before a farmer decides what to grow on a particular acre of land. For example, the decision whether to specialize only in crop production or diversify by including a livestock enterprise on a farm is of enormous consequence in determining the practicality of many other practices.

Perhaps another example will help explain this key point. Consider two neighbors--a conventional and alternative farmer--who for some reason moved into another county and happened to settle on adjoining farms where they decided to grow the same crop in their first season. In the first year of field work, the practices they would choose to employ might differ only marginally.

Important differences between the two farmers, however, would become increasingly evident over the years, reflecting the outcome of major decisions including what crops to grow in what order, or whether to integrate crop and livestock enterprises; the crops, tillage systems, and conservation practices applied on each field in response to its topography, soil type, or other natural resource limitations; and the level of dependence on inputs purchased off the farm per unit of production (that is, the percent of gross farm income per unit of output required to pay for the principle inputs--fuel, seed, fertilizer, pesticides, and animal drugs).

Several CAST reviewers criticize Alternative Agriculture for recommending alternative practices that have not been fully proven effective, except in certain narrow circumstances, or for which we lack detailed knowledge regarding both micro- and macro-economic consequences. They argue that the NAS report is reckless in encouraging change in conventional systems that work well in most instances. Again, this criticism misses our basic point that alternative agriculture is an approach to farming, not a distinct set of practices. It also ignores the history of technological advance, a record of steady progress that is absolutely critical in sustaining mankind's ability to feed itself.

For centuries, our ability to survive has rested upon the inclination of farmers to experiment, and in times of adversity, adapt to conditions threatening their capacity to produce enough food and fiber to sustain life. Throughout the 1970s and 1980s, innovative farmers were far ahead of most agricultural scientists in designing on-farm systems and methods to reduce cash costs, control soil erosion, limit chemical and energy dependence, and protect water quality.

Some farmers sought change to improve economic performance, others were more concerned with the environmental consequences of certain practices. Regardless of their motivation, farmers have historically proven very adept at innovation, both by trial-and-error and, in many instances, through more structured forms of on-farm experimentation. It would be a great loss indeed if we were now to discourage farmers from trying the unproven because science has yet to document carefully all possible consequences.

It is for this reason that Alternative Agriculture, in its research recommendations, places considerable importance on an expansion of applied, field-level research which includes farmers as active participants in the design and conduct of research activities, and in the communication of research results. We view this as absolutely vital because the science and art of farm management has for too long been one of the major missing ingredients in the agricultural science equation. We can think of no better way to overcome this historical shortcoming than by bringing the real managers directly into the research process.

The organization Practical Farmers of Iowa has already demonstrated convincingly the practical benefits of this approach. Incidentally, Practical Farmers of Iowa was started by Dick Thompson, whose operation is among those featured in the case studies of Alternative Agriculture (see case study number 5, page 308). In fact, the Thompson farm operation is now one of the most intensively studied anywhere in the world. Researchers from the USDA's Agricultural Research Service, the Iowa State University Agricultural Experiment Station, and a variety of other state and federal institutions and agencies are collaborating with the Thompsons on a variety of studies this summer.

It is worth stressing again that management skills and information are universally critical elements all farmers need both to diagnose problems with current practices successfully, and to discover ways to overcome problems or constraints consistent with available soil and water resources, machinery, labor, and market opportunities.

Traditional Strengths of U.S. Agriculture

Several reviewers feel that Alternative Agriculture fails to acknowledge the many strengths and accomplishments of American agriculture. Others are highly critical because the report recommends what they perceive as wholesale changes in proven agricultural research programs and institutions. Yet the Executive Summary begins with the following passage:

> "In the 1930s, crop yields in the United States, England, India, and Argentina were essentially the same. Since that time, researchers, scientists, and a host of federal policies have helped U.S. farmers dramatically increase yields of corn, wheat, soybeans, cotton, and most other major commodities. Today, fewer

farmers feed more people than ever before. This success, however, has not come without costs."

In several other places, the report highlights the outstanding successes of American agriculture. On page 137, Alternative Agriculture states that: "During the last four decades, agricultural research at the land-grant universities and the USDA has been extensive and very productive." Furthermore, the report calls for a substantial increase in public funding for agricultural research, through the very institutions we are criticized of belittling.

Alternative Agriculture does criticize existing research as too narrow in focus. The research system continues to reward narrowness, and has yet to attack seriously institutional and professional constraints to multidisciplinary, systems-based research. We conclude that: "The unifying premises of alternative systems are to enhance and use biological interactions rather than reduce and suppress them and to exercise prudence in the use of external inputs. Research has not fully addressed the integration of study results essential to the adoption of a number of alternative farming methods as unified systems...Lack of systems research is a key obstacle to the adoption of a number of alternative farming practices."

For this reason, two of the central research recommendations of Alternative Agriculture call for an expansion of systems-based research. We call for:

- A $40 million competitive grants program focused on the biological and ecological foundations of alternative production systems.
- A nationwide network of applied, on-farm research and demonstration projects that include farmers as active

> participants in the design and conduct of ongoing research, like USDA's current Low-Input Sustainable Agriculture, or LISA, program.

The CAST review, on the other hand, cautions that: "While the interdisciplinary and/or systems approaches may be useful in some cases...By using a systems approach, it becomes extremely difficult to establish cause-and-effect relationships." CAST reviewers also highlight a number of well-documented problems in carrying out systems-based multidisciplinary research. We agree with CAST that these problems can be serious, yet do not share its hesitancy in working toward meaningful solutions. Indeed, several concrete recommendations are offered to overcome these problems, both in Alternative Agriculture and Investing in Research.

We wish to be very emphatic here. American agriculture possesses great strengths upon which to draw as we face the challenges of the 1990s and beyond. Our experience with highly specialized industrial agriculture, with its reliance on pesticides and a relatively narrow base of genetic resources, is very short-lived when seen from the perspective of human history. We should not feel compelled to apologize for failing to anticipate the many subtle--and some not so subtle--problems that have arisen, but would be foolish to ignore them.

We will overcome these problems by drawing upon the traditional strengths of American agriculture--its natural resource base, the farmer-innovator, and the institutions that serve agriculture. Our rate of progress will accelerate if we augment ongoing research and on-farm experimentation with the insights possible through a systems-based analysis of the ecological and biological performance of farming systems.

A Return to Old Time Agriculture?

Some critics argue that an erroneously romantic vision of the good life experienced by family farms early in this century motivates much of the interest in alternative agriculture. They contend that adoption of alternative practices will condemn farmers to lower yields, reduced profits, and more drudgery. Furthermore, they argue that U.S. agriculture will lose the capacity to produce sufficient food and fiber to meet domestic and export demand; or, result in a marked increase in the price of food coupled with a reduction in the quality of food. In the CAST review, analysts predict that "widespread adoption of alternative agriculture" would reduce the food supply by 15% according to one review, or "up to 26%" according to another.

Quite to the contrary, alternative production systems are modern in every respect, and in fact require more sophisticated knowledge and more diverse technology than many conventional systems. Critics who dwell on this point are attempting to create a straw man. For some reason they seem convinced that a system that is based on the use of crop rotations, efficient management of animal manure, and other traditional practices can not also utilize modern machinery, crop and animal varieties developed with the advanced tools of modern genetics, appropriate levels and formulations of fertilizers, pesticides, and other modern inputs.

Will alternative agriculture result in a reduction in the food supply, an increase in food prices, or a loss in food quality, as some critics allege? We think not. Indeed, we believe that alternative agricultural systems will be essential in the 1990s to address pressing environmental, food safety, and competitiveness pressures, and to avoid trends toward steadily increasing food production prices and consumer food costs.

Moreover, alternative agriculture holds great promise in helping farmers adjust in response to changing state and federal policies. The 1990 farm bill and the need to reduce the federal budget deficit are bound to constrain somewhat the capacity of government to support farm income, share risk, and underwrite investments to the extent farmers have grown accustomed. In the longer-run, alternative agriculture holds great promise in leading American agriculture toward farming systems that attain increasingly high levels of production by building and exploiting the underlying productive capacity of soil and water resources. It will also help reconcile contemporary political tensions that arise whenever the Congress is asked to reconcile conflicts or broker tradeoffs among agricultural production, farm income, and environmental goals.

Throughout the 20th century, U.S. agriculture has taken advantage of the vastness and native fertility of the continent's landscape. But regrettably, there has been in nearly all major farming regions a slow but gradual loss of topsoil depth and soil organic matter content. In most areas, we have lost at least a third--and often one-half or more--of the organic matter content originally present when land was first farmed. To date, the loss of native fertility has been more than overcome in terms of crop yields by the addition to the soil of commercial fertilizers, crop residues, and other wastes.

The evidence is persuasive, though, that a new era has arrived for U.S. agriculture--indeed for agriculture in all countries that have aggressively adopted Green Revolution technologies. We should no longer count on existing technologies and inputs to steadily increase production levels consistent with demand through the next century, and if we try to do so, the world is likely to experience increasingly severe environmental problems, markedly higher food costs, and disappointing results in terms of overall production performance.

The reason is simple, yet its evolution complex and gradual. Farming practices over the last five decades or so have gradually degraded the underlying productive potential of the land. The cost and social tension surrounding the use of many contemporary technologies are bound to increase appreciably. In more and more cases--the emergence of pesticide-resistant pests and serious soil compaction problems for example--the biological performance and costs of once highly effective and profitable technologies are becoming unacceptable to society and a serious financial burden to farmers. Accordingly, in the long-run farmers will need to move toward alternative systems that actually build up the inherent productive potential of the soil, protect the purity of water supplies, and attain high yields with lessened dependence on nonrenewable resources. Reversing several decades of resource degradation can be accomplished in several ways: by a renewed commitment to reducing soil erosion to levels far below average rates today, by producing more than one crop per season so that the amount of crop residues and green manure worked back into the soil each year increases, by making better use of animal and other organic wastes, by more carefully managing water and controlling pest losses, and by ensuring that near-term financial pressures do not periodically compel farmers to adopt short cuts and forestall needed investments in soil and water conservation systems. In other words, through a commitment to alternative agriculture.

Mr. Chairman, we would be delighted to respond to any questions you might have, and if needed, provide for the record further responses to technical points raised by the CAST reviewers.

Thank you for the opportunity to participate in this hearing.

Representative **Hamilton**. Gentlemen, thank you for your excellent opening statements, and we are glad to have each one of you here. I would request that as each of you speaks that you pass those microphones around a little. I think it is easier for everybody to hear if we use the amplification system. We will proceed under the 10-minute rule for members that are present.

Let's begin just on the definitional problem. I want to clarify in my mind exactly what the differences are between the two groups in front of us here, the CAST group and the Board on Agriculture. How would you define the difference in a paragraph or two for me? Make it simple for me.

Don't everybody speak at once.

Mr. **Pesek**. In my view the main issue is whether we are doing as well in terms of environmental care and understanding in our agricultural practices as we know how to do. We have evidence that suggests that we are not as effective in using our resources and protecting them in the best way that we can.

I think that the basic thrust of an alternative farmer, or perhaps expanding the definition to a sustainable farmer, is that the farmer himself or herself takes a look at what are the consequences of the action that he or she takes in terms of farm management. They are driven by a concern that goes beyond only making a living. All the matters pertaining to alternative agriculture do stress the importance of having an economically sound agriculture that is socially viable and which has concern for the environment and productivity of agriculture for the needs of the United States.

Conventional agriculture tends to vary I believe considerably more because it readily and quickly accepts new ideas as well, and sometimes these ideas have been carried out to some excesses. So, there is the difference. If this were a perfect world, I would think that conventional agriculture would be alternative agriculture and sustainable.

Representative **Hamilton**. Now, Mr. Miller, how do you react to all of that?

Mr. **Miller**. Well, again as we said at the outset and I think as the report indicates itself, I think the definition is more tied up in differences of philosophy than in actuality. And I will just follow up on what Mr. Pesek indicated, and that is, in fact, if you look at the recommendations that come out of not only his own university, but any land-grant system and the USDA, these practices, if they were applied under good management, I believe would be environmentally sustainable and essentially compatible with the environment.

What you have out there across these more than 2 million operators is varying levels of management across varying ecosystems. Each has different risks. And yes, we are in certain cases being exploitive because of I think levels of management and the kinds of technologies or systems that are being applied out there.

But I come right back to a basic definition of agriculture. What we are trying to do is capture solar energy, and there is a variety of ways to do that out there. Each one of them has risks and tradeoffs. When you start looking at systems, each one of those has a risk and has a tradeoff.

Representative **Hamilton**. Well, when you look at the definition that is set out in the prepared statement by Mr. Pesek, he has, as I am sure you noted, a definition of alternative agriculture. What is wrong with that? That sounds all right, doesn't it, if you read through all those things?

Mr. **Miller**. "More thorough incorporation of natural processes such as nutrient cycles." No problem. "Nitrogen fixation, and pest-predator relationships into the agricultural processes." Philosophically I have no problem with that at all. The only concern is that in many cases there are not technologies currently available, for example, to take full advantage of pest-predator relationships without using other weapons in the arsenal of pest control. I think that is where we get hung up. We have no problem with the concept.

The concern is that manager out there has to deal with this problem today, not wait 10, 20 years for these new technologies to come down the road. And our concern is that some of these technologies are not available in packages that can be picked up to take full advantage.

Representative **Hamilton**. You do not disagree with that, do you, Mr. Pesek?

Mr. **Pesek**. No, sir. In fact, one of the real lacks that we have in the farming community is adequate information upon which farmers can act at the right time for their own benefit and for the benefit of the whole country.

Representative **Hamilton**. Go ahead, Mr. Miller. We were running down through that definition.

Mr. **Miller**. Looking at, say, "reduction in the use of off-farm inputs," no problem. I think if you look at the tradition of things like soil testing and a variety of other things, we are trying to have agriculturalists take samples to know what they have on their own farm before they purchase inputs. And our philosophy is that the inputs that are brought onto the farm should supplement the goals that are necessary and utilize what is already there. Again, we have no problem with that concept.

"Creative and productive use of the biological and genetic potential of plant and animal species." Again, from the standpoint of predator relationships, I think we are quite far down the road from having that adequacy to——

Representative **Hamilton**. What kind of relationship?

Mr. **Miller**. Well, again, coming back to the first point, the relationship of the pest-predators——

Representative **Hamilton**. I see.

Mr. **Miller** [continuing]. To take full advantage of the biological and genetic potential.

"Improvement in the match between cropping patterns and the productive potential and physical limitations of agricultural lands." Again, I could not agree more. I think one of the things that we're working on today in the Extension Service is to try to get farmers to be more realistic in their yield goals, and if they can do that, then they will not overapply materials, which we know is occurring out there in cases right now.

"Profitable and efficient production with emphasis on improved farm management and conservation of soil." I certainly have no problem with that concept.

Conceptually there is no problem here. To me it is a matter of where the technological packages are available to deliver all this.

Representative HAMILTON. Do you have any further comment, Mr. Pesek?

Mr. PESEK. Yes. One of the central thrusts of our report is that we do need to provide an opportunity to develop these technological breakthroughs that are necessary to achieve exactly what we are trying to do.

We have to have an agriculture that will sustain us not only to the end of this century, but the next century, and hopefully centuries beyond that.

And my personal concern and I guess the concern of our committee is that we are not asking the questions and not doing the research which really tells us how to keep our land where it is so we can continue to increase production of agricultural foods. And this is one of the main and serious issues that we pointed out. And I think that another report of the National Academy of Sciences published after ours also alluded to an increase in resources needed really to address the questions that are crying for answers in agriculture today.

Representative HAMILTON. Where is the nub of the difference here as a policy matter? Is it in research? What kind of research ought to be going on in agriculture?

Mr. RUTTAN. I think the issue is whether the technology is here or when it will become available. I am very concerned that the alternative agriculture agenda be pursued and that we have the kind of technology that we are talking about in the report. But my sense is that many of the people who have picked up the report have assumed or have interpreted it to say the technology is here and now. If we push it as a technology rather than as a research agenda, it will become discredited, and 20 years from now we will not have the technology either.

Representative HAMILTON. You are not opposed then to proceeding with research on alternative agriculture.

Mr. RUTTAN. I think it is absolutely essential.

Representative HAMILTON. And are you in agreement among you as to the pace of that research, how much emphasis ought to be given to it, or is that a difference?

Mr. PESEK. To my knowledge, we have not discussed the pace of this research. Our committee has made a recommendation which is only a small part of the recommendation for agriculture in general made later by a committee of the National Academy. And I would like to have Mr. Goodman comment on this if he wants to.

Representative HAMILTON. All right, sir. Mr. Goodman.

Mr. GOODMAN. Well, I just wanted to make a couple of quick remarks.

I think it is not inappropriate in my judgment that we examine different philosophies about what the future of agriculture should look like, although I think that to speak only to the difference being one of philosophy is to minimize an important difference that might be drawn between what the NRC report said and what many of the CAST reviewers have said about it.

The point simply is that we are talking about alternative approaches or alternative emphasis placed on the approaches or alternative emphases placed on the approaches used to manage the farming enterprise, and the focus in the alternative definition in managing biological resources in their complexity rather than trying to reduce them, which tends to be a characteristic of what we have come in many of our agricultural operations to regard and around this table I guess agree could be defined as conventional; that is, what is in use by the large proportion of farmers in a given situation.

I think it is absolutely true that the Alternative Agriculture report and the CAST review come down very strongly in agreement that we have a significant research agenda ahead of us and that we have very strong common ground on which to pursue that agenda.

Representative HAMILTON. We will come back to some of these things. My time has expired.

Senator Symms.

Senator SYMMS. Thank you very much, Mr. Chairman.

First, Mr. Chairman, I want to say I have 30 questions, and I would like to get into the last 5 questions before I go back to all the others.

But my first question is how would you define—I want to ask this question to both Mr. Miller and Mr. Pesek just in a brief answer, if you could—what I learned as integrated pest management from land-grant institutions at Washington State University and the University of Idaho, at least from my own personal involvement in it. Is that alternative agriculture or is that what we consider conventional? We were looking for an alternative to reduce our costs and use less chemicals. Does that fit your definition?

Mr. PESEK. In my mind integrated pest management is a facet or piece of alternative agriculture or sustainable agriculture, if you wish. Once it gets completely accepted and incorporated in the system, it will be the conventional agriculture of the day, just as use of DDT to control houseflies at one time was a conventional method of controlling houseflies.

Senator SYMMS. Mr. Miller.

Mr. MILLER. I agree that IPM is a tool. It is one of the tools in the arsenal of production agriculture. I agree completely.

Senator SYMMS. Right. So, you don't have a real conflict on that issue, in other words.

Well, Mr. Chairman, I note that Mr. Gary A. Lee is here from the University of Idaho Experiment Station. I wanted to ask him a couple of questions, if it would be appropriate, that deal with the fresh produce, unless there is someone else here that wants to do it.

Representative HAMILTON. Mr. Lee, could you come forward? Make room for him, if you can, at the table, and you can speak into the mike. We are glad to have you, sir.

Senator SYMMS. And I welcome you here, Gary. Good to have you in town.

The Alternative Agriculture report suggests that increased labor can substitute for chemicals to address weed and pest control objectives. With respect to potatoes, how much of an increase in labor would be required to compensate for the nonuse of chemicals? That is the first part of the question.

The second part, is the labor market in traditional potato growing areas able to supply this increased demand in your opinion?

Representative HAMILTON. You better sit down before tackling those questions, Mr. Lee, I suspect. [Laughter.]

TESTIMONY OF GARY A. LEE, PH.D., IDAHO AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF IDAHO

Mr. LEE. The first part of the question, we have done some evaluation of labor requirements in various crops in Idaho and in particular potatoes. We have, on a small plot basis, looked at this problem, and with a moderate infestation, it can be 120 to 130 hours of labor in addition to some mechanical operations.

Senator SYMMS. Per acre?

Mr. LEE. Per acre.

Senator SYMMS. So, you are talking about at $4 or $5 an hour, an additional $400 to $500 or $600 per acre.

Mr. LEE. It very well could be.

Senator SYMMS. And if the farm produced 300 bags per acre yield, we would be talking about adding to the cost of production about $2 a hundredweight. Is that correct?

Mr. LEE. Yes, that is correct.

Senator SYMMS. So, in that respect, that could have a tremendous impact on the price of potatoes nationally.

Mr. LEE. Very much so.

Senator SYMMS. Mr. Lee, one of the contentions of the Alternative agriculture report is that government programs, that is, price support programs, have caused artificial incentives for high input use of agriculture. Now, if this is true—and it may well be true—why then do nonprogram crops like potatoes, carrots, onions, the other vegetable crops, fruits and vegetables have higher fertilizer and pesticide use per acre than program crops?

Mr. LEE. It would be in my opinion, Senator, that it is driven by consumer demand. There is a demand by the housewife, the produce distributor to have a high-quality product. It is economically feasible for the housewife to buy produce that has little waste, and therefore that is her desire when she is shopping in the supermarket. By today's standards, they will not purchase potatoes that are knobby or have insect damage or disease damage. So, it is by virtue of the demand for both fresh product and processed potatoes——

Senator SYMMS. Would that same question be appropriate with an alternative use? The report recommends using more legume crops, animal manure, so forth, to provide the nitrogen for potato crops. How would that affect the quality of the Idaho baking potato?

Mr. LEE. In today's rotations, in Idaho specifically——

Senator SYMMS. Also in Oregon and Washington, it is pretty much similar.

Mr. LEE. Yes. We use legumes in rotation.

Senator SYMMS. In rotation.

Mr. LEE. In rotation. Potatoes cannot be grown in a monoculture because of disease problems, insect problems, so forth. So, I think we are using a number of the same recommendations that are recommended in Alternative Agriculture, but to rely on the manure and legume for all of the nutrients for a potato crop is not feasible.

Senator SYMMS. Would it be customary to go into alfalfa, and if you took a field out of alfalfa after, say, 3 or 4 years of alfalfa to grow potatoes and then grow grain, then grow potatoes, then grow grain?

Mr. LEE. And then back to grain, and then back to alfalfa again.

Senator SYMMS. That is typical of what happens.

Mr. LEE. Yes.

Senator SYMMS. How about the use of animal manure? How well can you meet the balance on that?

Mr. LEE. Certainly animal manure is a reliable source and a proven source of nitrate nitrogen for production of potatoes. However, if we look at the nutrient requirements for the potato crop in Idaho, we virtually do not have enough contained animals in the State to provide the manure for the crop.

Senator SYMMS. Well, thank you very much.

Back to the nitrogen question, there has been some concern I think that we have all been interested in and concerned about, and that is the nitrogen contamination of groundwater. Now, if there were sufficient materials available through mulching and manure, would that have an impact on groundwater nitrates?

Mr. LEE. The available form of nitrogen for plants is the nitrate form. It is water soluble whether it comes from an organic source or an inorganic source, and both are subject to leaching. And so, once that nitrogen reaches a nitrate form, it can be leached, it can move in the soil as a water soluble product.

Senator SYMMS. Well, which one is easiest to control then?

Mr. LEE. Certainly the known quantity, the off-farm type nitrogen can be precisely prescribed. It is something that we know the percentage and the amount of. The farmers can apply it, as Mr. Miller says, in the amount after they know what is available in the soil from soil testing programs.

Senator SYMMS. Do you think it is fair to say that potato farmers, generally speaking, will try to use the minimum amount of nitrogen fertilizer necessary to grow the high-quality product?

Mr. LEE. Yes. It is a profit motive. It is a very real cost of operation, and certainly they need to minimize those costs.

Senator SYMMS. Well, there is a suggestion in the report that the consumers should be prepared to accept lower quality food products and that inspection standards should be lowered to facilitate market entry of alternative agriculture products. You have already mentioned that people do not want knobby potatoes or, as I have often said, they do not want wormy apples.

Does this mean tuber consumers should accept malformation, discoloration? How likely is it consumers are going to respond favorably to that kind of a standard change or lowering or reduction?

Mr. LEE. In my opinion in most grading standards, ARA consumer protection program, it is a means by which produce can be purchased, and if it is a U.S. No. 1 product, it will meet certain standards for that.

For example, a grading standard problem with potatoes is green potatoes. And a green potato contains glycolalkaloid which is toxic to humans. It is a toxic product naturally occurring. And it also indicates that those potatoes have probably been mishandled. They have been exposed to long periods of light, and therefore would not store well. So, it is those kinds of standards that help protect the consumer.

Senator SYMMS. Well, thank you very much.

Mr. Chairman, thank you for your indulgence, and I do have more questions, but I will wait for the next round.

It was my understanding Mr. Lee prepared a statement, I would like to ask unanimous consent that it be inserted as part of our hearing record.

Representative HAMILTON. Without objection, Mr. Lee's prepared statement will be made part of the record.

[The prepared statement of Mr. Lee follows:]

PREPARED STATEMENT OF GARY A. LEE

Statement on NRC Report: Alternative Agriculture

I am pleased to have an opportunity to comment on the NRC report entitled "Alternative Agriculture." My comments will be confined to the application of the report's recommendations to the production of potatoes generally in the United states and specifically in the western region of the nation.

Approximately 1.2 million acres of commercially grown potatoes were produced in 38 states in 1989. Idaho led production with 350,000 acres with a farm value of over $630 million. Growers in Idaho have been able to maintain a significant share of the national market while isolated from major metropolitan areas. The major contributing factor is the ability to produce and deliver a superior quality product for both the fresh produce market and the processing market throughout the year even though the crop is harvested in October. Production and storage technology have been the key for potato producers to meet the consumer demand for quality potato products.

The NRC report has advocated a number of agricultural production practices which, if mandated by law or policy, would severely impact the ability of the nation's potato industry to produce the quality and quantity of America's most popular vegetable. Salient points which should be considered are:

1. Potatoes are a perishable crop which are not subsidized by government programs. Yet, production of a potato crop which meets consumer demands requires substantial off-farm inputs, and for the most part, the crop must be stored under controlled conditions until consumed through fresh or processing markets. The report statement (PAGE 10) "many federal policies discourage adaptation of alternative practices and systems by economically penalizing those who adapt crop rotations, apply certain soil conservation systems, or attempt to reduce pesticide applications" cannot be implicit for all crops.

2. Potatoes cannot be grown in monoculture nor can they be produced without extensive off-farm inputs such as fertilizer, pesticides, and specialized production and storage equipment. Such investments are made with out the support of governmental programs.

3. Nutrient availability and regulation is paramount in producing a potato crop which meets industry and consumer standards and one that has a reasonable profit margin for the producer. The NRC report infers that off-farm sources of inorganic nitrogen fertilizer are undesirable and that only organic nitrogen sources (plant residue and animal manure) should be used for crop production. Regardless of source, nitrate forms of nitrogen are water soluble and will move in the soil profile with the potential of reaching the sub-surface groundwater.

4 Potatoes are grown in rotations with other crops which often include legume crops. The legume crop can provide up to 50% of the required nitrogen the first year after the organic material is plowed under. Some benefit can be realized from the legume crop for up to four years, but supplemental nitrogen and other plant nutrients are required.

5. If livestock manure became the sole source of nitrogen for the 350,000 acres of potatoes produced in Idaho, the number of confined dairy animals required to produce the organic material would be increased from 168,000 head presently to over 875,000 head of animals or a five fold increase. This example does not consider the impact on excess production of milk, cheese, and other dairy products, red meat production, or other sectors of the livestock industry or the expense and logistics problems that would result from manure storage, transport, and application.

6. The NRC report (PAGE 13) concludes that there is a propensity to retain old pesticides at the exclusion of biological control, genetically engineered resistance crops, and integrated pest management (IPM). It must be emphasized that all of these modern pest control measures are being actively pursued and that pesticides are being retired voluntarily. Ironically, there are a number of naturally occurring microorganisms which have been identified with the he potential to control potato diseases. Yet, the federal government has rejected all applications for registration and commercial use as biological control agents.

7. Weeds, diseases, insects, and nematodes (microscopic-parasitic worms) pose serious threats to the production of quality potatoes. Growers simply must use safe pesticides when necessary as a crop protection tool. They to monitor fields and apply pesticides prudently because of the significant additional expense which adds to the cost of production. Potato growers are "stewards of the land" and must protect the natural resource from the invasion of unwanted plants unlike the example presented in the NRC case study (PAGE 282) that states "the unique feature of the Fisher's cropping system is their view of Johnsongrass and other weeds: they no longer focus on trying to eliminate them but instead cultivate them as a source of feed for the livestock operation."

8. The NRC report (PAGE 12) states that "Federal grading standards or statements adapted under federal marketing orders, often discourages alternative pest control practices for fruit and vegetables by imposing cosmetic and insect-pest criteria that have little if any relation to nutritional quality." Grading standards have been established to protect consumers. Green potatoes are a defect in the fresh potato grade standards and for good reason. Potatoes exposed to light produce glycoalkaloids which are toxic to humans.

9. Without question, greater investment in research and development for new technologies is needed to provide solutions for water pollution, soil erosion, and to reduce production costs. Policy makers, however, must proceed with caution in attempting to address the problems with more restrictive regulations without providing viable solutions and alternatives.

In conclusion, I must emphasize that the University of Idaho and other Land Grant Universities are actively engaged in research to develop alternative management systems to conserve our nation's natural resources, improve the environment, and maintain a high quality, safe food supply. Agricultural producers have historically been quick to adapt new technology which is proven to be agronomically sound and economically feasible. New technology is needed to improve the quality of our nation's water supply and maintain our fertile land. However, regressing backwards to force the use of production practices of four decades ago will jeopardize our ability to maintain a strong agricultural industry. Low input agriculture does not mean low technology. We must continue to develop pest control practices, disease resistant varieties, nutrient and water efficient crops which will be compatible with our goals to maintain and improve the environment and quality of life for future generations.

Senator SYMMS. And, Mr. Chairman, in your absence I had asked unanimous consent to add another report to the record, and I would ask unanimous consent that all of the witnesses' prepared statements be put in the record in total.

Representative HAMILTON. Without objection, that, of course, will be done.

We are very pleased to have with us two Members of Congress not on the Joint Economic Committee, but very knowledgeable in agricultural matters. Congressman Jontz of Indiana and Congressman English of Oklahoma. And the Chair recognizes Congressman Jontz.

Representative JONTZ. I thank the chairman and commend him and the committee for this hearing. It is certainly very timely with the work that we have ongoing in the House Agriculture Committee. Many of these issues are issues that we are debating and will be addressed in different ways in the 1990 farm bill. I appreciate your hospitality, Mr. Chairman, and have appreciated the dialog also and have just a couple of questions I would like to ask.

With the chairman's permission before proceeding to a question or two, I might recognize that we do have present in the audience today my neighbor, Jim Moseley, from Clarks Hill, IN, who is the administration's new selection for Assistant Secretary for Natural Resources for USDA. Mr. Moseley is a production farmer from home who has been serving the administration quite capably as agriculture adviser to the Administrator of the Environmental Protection Agency, and I think it might be appropriate to recognize his presence here this morning.

Representative HAMILTON. Thank you very much. Mr. Moseley, put your hand up. Very good. We are delighted to have you. Thank you for joining us this morning. Thank you, Congressman Jontz, for calling that to my attention.

Representative JONTZ. Thank you again, Mr. Chairman.

I guess I will ask Mr. Miller this question. We have had some discussion this morning about increasing crop rotations and implications of that, and in your statement you identify environmental tradeoffs of increased forage production as a concern that was not addressed in the NRC report.

Could I ask your response in terms of whether you feel that the report put too much emphasis or not enough emphasis, or just how you feel, about the benefits of such rotation and increased forage production affecting the long-term productive capabilities of soil, particularly water retention capabilities of soil, particularly water retention capabilities and what impact that has on yields over time? Do you feel like that there is some relationship there that ought to be considered?

Mr. MILLER. Well, clearly there is well over a century of evidence both in this country, as well as in Europe, at experiment stations on replicated research plots that rotations are a sound husbandry practice. That type of research also clearly shows the enhanced soil health, soil till, soil condition under grasses, under forages and when they are put in the rotations. There is absolutely no question about that.

The concern is that many farmers opt to grow the kinds of crops they do for a variety of reasons, lifestyle choices. We are getting a situation today across much of the Midwest where farmers are simply saying I like this type of an operation in the sense that I do not have to deal with animal agriculture. And when you take animal agriculture out of an operation, you forfeit a number of good husbandry practices. You shorten your rotations. You take legumes, forages, pastures, grasses out of that rotation. And we know that those are excellent husbandry practices. And therein you have a tradeoff of what that lifestyle is going to be.

The report indicates that whole farm research should be done, and we completely agree with that. Others have said that perhaps the whole farm is not the unit that should be studied. Perhaps we need to broaden it and to bring in the social issue because one of the things that current technology allows farmers to do is to have either themselves or spouses employed off the farm to generate extra income. If we are going to increase the management requirements or bring animals back into that operation, we have those tradeoffs. The are environmental tradeoffs, economic, and social tradeoffs.

Representative JONTZ. Part of your point is that the producer may by choice decide that he does not want to be in the livestock business, but at the same time there are many other factors that may make the livestock end of an operation less attractive economically. We are all familiar with the changes that the livestock industry has been going through.

Do you think that if, say, producers had base protection, maybe received deficiency payments in some circumstances for a forage crop, that there would be some change in the balance of economics so far as livestock production is concerned that would make more decentralized production more of an attractive alternative economically for the producer that wanted to do that? Is that possible?

Mr. MILLER. Oh, I think it is. I think the report has clearly pointed out—and I wholeheartedly agree—that government programs have driven a great deal of what we see out on the landscape today.

I would like to defer, if I might, to Mr. Hays here on my right, an animal scientist, to see if he could respond to that.

Representative JONTZ. Thank you.

Mr. HAYS. Thank you, Mr. Chairman, for having us.

Congressman Jontz, a marked increase in bringing the legumes and so forth into rotation would I think require some marked increase in the ruminant animal out on that farm. We are always on the verge of the numbers needed to meet the demand. So, any marked increase in, say, dairy cattle or beef cattle would have an impact on the economics of growing those animals. So, I think to go very far in, say, utilizing legumes as a major source of nitrogen to replace commercial fertilizer would necessitate utilizing that or charging the total cost of the legume to the succeeding crops.

And this probably has not been adequately addressed in the report, what would happen to the numbers necessary to utilize those?

Representative JONTZ. Well, I appreciate that point. I guess what I wanted to hear some response to is also whether you think that there would be any change in the relative economics? Sure, on a short-term basis, you are talking about more animals, but does it change the landscape economically so far as the viability of that form of livestock production as compared to concentrated feeding operations? And we have seen a shift occur for any number of reasons, and I guess my question is conceivably, would increased production of legumes with some economic protection for the producer change the balance?

Mr. HAYS. Well, the economic incentives for the producers to grow more livestock would probably get you into some of the same problems that we have had with economic incentives for other crops as to immediately lead to surplus. We are producing as much milk and beef right now as the consumer demand will take at a profitable price.

Representative JONTZ. I appreciate that, but the question is, who is going to produce for the demand that exists? It seems to me you change the relative balance of the means of production, the methods of production when you change those elements in the equation.

Mr. Goodman is shaking his head yes. I guess he understands what my question is. I am not sure I am being very clear. That is probably the problem.

Mr. RUTTAN. Let me comment, and it is also related to this issue of nonprogram crops that was brought up before. I think the way to start out thinking about it is to recognize that the way we run our agricultural program is that Federal Government rents, depending on which year, somewhere between 10, 15, or 20 percent of the land in American agriculture. Anytime you go out and rent that much land, you are going to affect the price of land. And we have artificially made land more scarce. That has provided an incentive for farmers to use land substitutes both in the way they manage their farms and the inputs they buy, and fertilizers and pesticides are land substitutes. It is clearer in the crop agriculture than in the animal.

But if we were to design a farm program that did not operate by renting land, we would find a change in the way we produce crops and in the way we produce animals, and we would create different incentives for agriculture research. When you create an incentive to substitute for land, you create an incentive for the private sector agriculture research and the public sector agriculture research to invent substitutes for land.

So, there are significant implications, that affect program land and nonprogram land. So, there are significant implications for the structure of agriculture in the way we have been running our farm program.

Representative JONTZ. I think my time has expired, Mr. Chairman.

Mr. BENBROOK. Congressman Jontz, might I add about half the pounds of beef produced in the United States are done so in a feed lot. The feed lot industry is heavily concentrated in the high plains of Texas, Kansas, Oklahoma, and Nebraska where a combination of policies in the 1960's and 1970's created through the Tax Code some very favorable incentives for the establishment of large feed lots. We established feed grain base acres for irrigated operations where the producers also received rapid depreciation and investment tax credit for the installation of the irrigation systems.

Under the feed grain policies, the operators of feed lots were actually one of the greatest beneficiaries of the feed grain policies of the 1980's, which were so crucial to keeping your corn farmers in business in Indiana. A feed lot operator or a hog producer buying $1.25 cash corn is also a major beneficiary of the commodity policies that we have had in the 1980's.

So, if you look at the combination of policies, American agriculture has gone where the economic opportunity is which has been very large, concentrated feed lots with government subsidized feed grains and generally some very attractive investment policies that have helped return the cost of the capital of putting in the irrigation and the water depletion allowance and all these other policies.

And what Alternative Agriculture suggests is that it is incumbent upon the country to think about the broader range of consequences. These policies have not helped the Indiana or Iowa or Ohio small feed lot operator. But what is happening now is we have already changed the Tax Code, and a lot of the costs now for the feed lot industry are beginning to increase.

And I think without any change in policy, we are going to see a gradual migration of lots to the North. They will be a shorter period of time. The average animal spends 134 days in feed lots now. Twenty years from now it might be down to 90 days. And that extra 44 days on feed will probably be in a forage based operation. And that kind of shift is going to occur very gradually, and it is going to require millions of additional acres of alfalfa and other forages. And that will free up the good land in the Midwest and elsewhere to produce feed grains for ethanol, assuming you get a clean air bill through, and other things.

So, I really think that we have to recognize that a combination of policies, not necessarily recognizing how they are all going to work out, has had a profound impact on what we grow and where we produce it.

Now, in the base flexibility provisions and the question that you asked specifically, you know what happened when the Congress provided the 25-percent substitution option to grow soybeans on feed grain base acres. Relatively few farmers, despite the strong market demand for soybeans, exercised that option because it still made more sense to farm the corn program and take the deficiency payment.

I fear that the same thing will happen if the current flexibility proposals that are being worked on are adopted. Farmers will have the opportunity to grow forages on their feed grain base acres, and can do so at the sacrifice of their deficiency payment. And most of them will pencil it out and realize that it is not in their economic interest.

So, I think your question about what happens with that forage, it certainly needs to be harvested and perhaps some payment in order for the economics to sort themselves out.

Representative JONTZ. Well, my time has long expired.

I appreciate that helpful answer. In fact, one of the flexibility options, mine which is introduced as H.R. 3552, would pay deficiency payments on conservation crops as part of a rotation. So, I appreciate your point, and again I appreciate the patience of the chairman.

Representative HAMILTON. Congressman English.

Representative ENGLISH. Thank you very much, Mr. Chairman. I want to commend you for these hearings. I think this is an excellent opportunity to air what is a very important subject. Both Congressman Jontz and I being on the House Agriculture Committee, we are vitally interested in this in trying to deal with some of the problems farmers face.

I suppose, though, that I think that our panel has done a good job of beginning to grasp some of this, and that is that we are dealing with an extremely delicate economy that has, over history, been whipped in one direction or another by elements beyond not only the control of the individual farmer, but many times beyond the control of the U.S. Government. And certainly weather still probably plays as big a role around the world on many of our commodities, particularly those that are aimed for export than what we do in government policy.

But that be what it may, I think that there is no question there are some directions that we would like to make some adjustments in that I think are wise not only from the standpoint of the overall national good, whether it be from the environment standpoint, but also from the standpoint of the farmer. But I think in doing that, it has to be done in a very careful manner.

One of the things that troubles me more than anything else is that we have a lot of folks going around with a lot of theories, and I am just wondering how many real facts they have to back up those theories. This would be one area in which I think it would be very easy for the Congress, for instance, to jump in and make major adjustments as far as this nation's foreign policy is concerned and discover 4 or 5 years from now that we have a first-class disaster on our hands, a real catastrophe. And I think that we have to be sensitive to that. I think we have to recognize that.

So, I would hope that as we move toward making some of these adjustments and changes that we do so with the understanding that there is a lot still to be learned, and that we have to recognize that agriculture in this country varies tremendously from region to region and certainly State to State. You were mentioning the situation of feed lots. Most of these feed lots happen to be in my district in Oklahoma, and so we are very sensitive to that.

Also, we deal with problems such as we have in Oklahoma and much of the Great Plains area in which wheat is about the only thing we can grow. There is not really much that we can switch to. And as we make these adjustments that may fit in one region, we may find that that has some very harmful side effects in other parts of the country.

I guess I would like to see from any of our panelists a little more of a discussion rather than focusing just on one aspect of this whole question of what does this do and how can we adjust government policy and at the same time being fully aware and sensitive that we do not want to destroy the agriculture economy in any particular area of the country or any particular region or for any particular crop, for that matter.

Mr. Benbrook, I will let you start off, and if you could, just go down the row. I would must like some very brief comments on what you think about that.

Mr. BENBROOK. Well, I think that the history of agricultural policy over the last 20 years has been a continuing series of unfortunate miscues with the calendar. Think of the first farm bill you passed in 1981. Wouldn't you have loved to have had it back? A year later you realized that you passed a farm bill that made great sense for the end of the 1970's, but was very detrimental to agriculture's interest in the early 1980's.

Representative ENGLISH. I voted against it. [Laughter.]

Mr. BENBROOK. What this report calls for is a shift in the emphasis that people bring to an analysis of American agriculture, a shift in the emphasis that the farmer, when he is thinking about what to plant, how much fertilizer to put on. The question is not how much fertilizer; it is how to get the right amount of nutrients in the way of the roots at the time the plant is ready to grow. That is the issue everyone at this table would agree with. It does not matter whether it is fertilizer, manure, or legumes. The issue is not having too may nutrients in the soil profile at the time when water is flowing down through it because if you do, it is going to leach.

So, I think that the critical question is how can we change——

Representative ENGLISH. Could I stop you right there and add one other ingredient? In many parts of the country, we have different kinds of soils. The soils themselves may play a very big role in the so-called question of groundwater that is contaminated. Can you distinguish between the two? How do we determine in an area where we simply have soil that is providing the problem and not necessarily the farming practice as opposed to the area with a farming practice?

Should we be proceeding around the country in attempting to identify the various kinds of soils that we have in the different regions?

In other words, I guess what I am getting into is rather than a simplistic approach and simply saying, OK, *x* amount of this fertilizer applied under these conditons, everything is great. Well, that may work for one area, but not work for another, as I understand it. How do we address that aspect to work that into the formula?

Mr. BENBROOK. I completely agree with you that because of the variability of the natural resources that farmers have to work with, it would be impossible to develop precise, quantitative recommendations or limits on how much can be applied in one place or another. A set of concepts have to be used, though, that are biologically and physically based, draw upon ecological principles to get the most out of land that can be grown in any one year without destroying the underlying productivity in the long run of the soil and water and without contributing to excessive off-farm environmental problems. That is the goal that everyone has foremost in our minds, and the question is, how do we get there?

Our report identified a series of Federal policies, priorities within our research programs, that are not optimum anymore in helping to move us in that direction. And I think that that is the major point that I would make, and I am sure Mr. Pesek, as quite an expert in the soils of Iowa, could speak to some of the variability issues.

Representative ENGLISH. Well, I would like a brief comment from all of you, if you could, please.

Mr. GOODMAN. Well, I am not a soils expert, but I will say that I know that over the past several decades, especially quite a while ago, a substantial investment was made by the U.S. Department of Agriculture in the land-grant system in doing exactly what you suggest, which is understanding the underlying soils in a very detailed way that agriculture is practiced upon in this country.

And one of the things that I would just cite on the research agenda is that it might be appropriate to go back to that base and ask the questions not only about inorganic fertilizers, but also about the microbiological communities that exist, for example, in these various soils and how they might interact with the plants that we grow or do not grow and might grow, the development of new alternative crops. You are probably familiar with one alternative that you have in Oklahoma which is canola.

And there are a whole series of questions when you bring in new production practices or when you bring in new crops that we now have new tools from genetics and microbiology to study, but we do not have the resource base committed to that level of research that would be analogous to soil typing and soil analysis and soil classification such as was done in the 1930's and 1940's and into more recent years.

Representative ENGLISH. Mr. Pesek, how far along are we on all this, understanding exactly what we are dealing with the different soils?

Mr. PESEK. The Comprehensive National Soil Survey—Mr. Miller might correct me—is virtually complete. In our State we are remapping some counties which were mapped a long time ago, and we are about one-third or one-half of the way through computerizing all the county soil maps in the State of Iowa. And I think this will be done in every other State. Minnesota I know has been doing it. Others around us have, too. So, we do have an excellent inventory of the soil resource in the United States, if not already, very close to completion. So, this is one source.

The need then becomes one of providing the users of the soils with the tools and the information that lets them optimize the use of those soils for their own benefit and the benefit of society in general. And this I think is where the greatest lack of information exists at the present time.

One of the economists at Iowa State University said that conventional agriculturalists tend to treat all acres as if they were the same whether they have a high-yield potential or a low-yield potential. We know in terms of plain economic theory that this is not rational behavior. Why did they behave this way? Because they do not have the information and have not had the information to make the distinction on an orderly basis.

In some cases, there may be a matter of technology. For example, if one sets a fertilizer spreader to spread 100 pounds of N, one really cannot very effectively, yet, open it up a little bit at the right places on the landscape and shut it down again in another place. With the GIS system coming into existence, and satellite mensuration, farmers will be able to change their fertilizer rate every 10 feet or maybe even more frequently if needed based on an input from a computerized map in the computer on the tractor.

The same applies to controlling weeds with herbicides. The tendency now is that if a field has weeds in it somewhere, one treats the whole field. With better information and good technology, farmers could treat only those places where treatment is needed sparing the environment of carrying the load of unnecessary materials on the rest of the field.

So, we have the technical capability to do many things that we are not doing because of the lack of information delivery and information sources for people who actually farm. I am wondering in my own mind whether in the future we may not have a large industry develop of people who simply convey information to farmers. Information for which farmers will pay every year to make the right choices on their particular farms. Let the farmers worry about their income, lifestyles, farm programs, and all these things, but let the technician deal with the inputs that are needed and used in a timely basis and an appropriate level of intensity.

I think that the opportunities are great, but we cannot take advantage of them if we do not spend more time studying practices as a group; interdisciplinary studies involving agricultural engineers, plant scientists, plant breeders, soil scientists, animal scientists, and so forth, to address particular problems together rather than pursuing a very narrowly focused research agenda each on his or her own. I believe these are real possibilities.

And the consequences attributed to agriculture, whether or not they really are, I think are real serious. We brought a copy of the Des Moines Register with us which tells about the nitrate problem in Des Moines. The Des Moines waterworks blends two sources of water, at least, to keep the nitrate level below the published Public Health Service limit. And in other action in our State, the Des Moines City Water Department has advised pregnant women and those having small children to select bottled water instead of using the city water. These are serious problems. Whether they are all due to agriculture, we can answer in due time, but they are blamed on agriculture today.

Mr. MILLER. Well, I have not heard anything yet that I would disagree with. I would make, therefore, two quick comments.

I think if you followed up on this hearing in looking down at my crystal ball, say, 20 years from now, I think the people sitting at this table in response to that inquiry would say that we are now dealing with a much more prescription-based agriculture. We are going to be dealing with knowing what our response curves are out there and therefore making inputs accordingly after we have already utilized the onfarm sources. If farmers could predict the weather as to what the growing season would be, I think you would also see a great deal of shift and reduction of environmental impact perhaps from overuse of some resources.

The way we are trying to get at that today is trying to take last minute checks, even after the growing season starts in the early spring, to make decisions on the inputs. That technology has been alluding us for about 70 years from the standpoint of nitrogen, which is obviously one of the major inputs into the production system. Many States now are developing nitrogen tests, petiole tests, other kinds of tests, just like soil tests, and that is an example that I think we will see in the future to deal with a prescription-based agriculture which we must have.

Mr. HAYS. Congressman English, I grew up on that western Oklahoma area, so I know what you are talking about. And I was on the faculty at Iowa State for 10 years, so I have seen cattle fed there as well.

Back to the livestock area, there are some definite advantages to feeding cattle in the high plains area that are not prevalent in the upper Midwest. This does not say that we cannot do it in both places, but we have fed cattle in Iowa. When they go to market, we have estimated they have had 100 pounds of frozen mud and ice on their backs. So, that does have an impact on the cattle prices, the performance, and so forth.

Most of the animal wastes that are present are going back onto the land, except possibly in the feed lot concentrations in the high plains area. And so, we are utilizing those manures to a large extent at the present time.

We have talked about the conventional agriculture differing in each section of the country. So would alternative agriculture. And it is an evolving process that what is alternative agriculture today is conventional agriculture tomorrow. And we are still incorporating integrated pest management as alternative agriculture, but it was sound policy before we started talking about LISA and alternative agriculture to the extent that we have. So, we are in an evolving process.

One comment I would like to say about the research needs is that we do need more system research, but this does not mean that we need to cut back on the discipline oriented research and substitute for that because we are going to need the basic information to develop into a system that will be effective whether we call it alternative agriculture or conventional agriculture.

Mr. RUTTAN. I would appreciate an opportunity to look a little further into the future if possible. I want to do that because I am concerned that American agriculture is one of the few global class industries we have. I can remember when automobiles and steel used to be global class. And along with the chemistry industry, agriculture is one of the few industries that is capable of generating export earnings.

I see, as I look into, say, the second decade of the next century, that the approach that we have used to get productivity out of agriculture is going to run into some constraints. And I am drawing on a couple of international discussions that I have organized. But basically the way we have had increases in crop productivity in the past 50 years is to change the ratio of grain to straw, and we are getting that down toward 50 percent, the ratio of straw to grain. The way we have had increases in animal productivity is to reduce the amount of feed that goes into animal maintenance and increase the amount of feed that goes into animal products. Those conventional sources are going to be playing out. We are still getting a 1-bushel-a-year increase in corn, but that is a much smaller percentage increase when the base is 120 or 130 bushels than when it was 30 or 40.

At the International Rice Research Institute, rice yields under maximum yield experiments had not risen for 20 years. Every 10 years the promise of biotechnology recedes 8 years. [Laughter.]

What people were predicting would happen in the 1990's, they are now predicting will happen in 2005.

But I see within about a generation that we will be able to have a new source of raising ceilings that will be more science based. That is where the biotechnology is heading, but it is not moving there rapidly enough. And if we are not able by 2010 or 2020 to move to a new scientific base, then we are not going to be able to maintain a world class agriculture industry and the poor countries of the world are not going to be able to feed themselves.

Representative ENGLISH. Thank you, Mr. Chairman.

Representative HAMILTON. Thank you, Congressman English and Congressman Jontz. We appreciate your contributions.

How many farmers in America today follow alternative agriculture?

Mr. PESEK. I wish you hadn't asked that question. I do not know the answer.

Representative HAMILTON. Are we talking about 1 in 10, or 1 in 100, or 1 in 2, or what?

Mr. PESEK. Well, it is more than 1 in 100. I suspect it is more than 1 in 10, or maybe close to that, if one considers the whole set of practices. If one considers individual practices, such as reduced tillage for production of corn in the Corn Belt, then there is a tremendous number that have adopted that—reduced tillage—as part of a conventional system, and only 15 years ago they were plowing the land——

Representative HAMILTON. Are there geographic areas of the country where alternative agriculture is much more prevalent than other areas?

Mr. PESEK. I think that it would be easier to adopt certain systems of alternative agriculture in the Corn Belt than in some other places because of the different kind of environmental problems with which farmers have to cope. It may not be possible to take care of insects as readily in the southeastern United States as it is in the north-central region or in the plains and maybe even in California. In fact, studies have shown that it is easier to control insects and plant pathogens in California than it is in Florida. So, there are many differences.

And I think that the crying need is to address the serious problems where they are the most critical and to address these rather than try to solve them with what has been called a quick fix with some kind of a chemical method.

Representative HAMILTON. Was one of the purposes of the Board on Agriculture report to encourage farmers to turn to alternative agricultural practices? Is that one of your objectives?

Mr. PESEK. Well, our charge really was to see if alternative agriculture practices had any place in modern mainstream agriculture, and our conclusion was that they do. Now, we were not asked to——

Representative HAMILTON. You view yourselves as kind of advocates of alternative agriculture I gather.

Mr. PESEK. Not advocates. We simply took a look at what was available in the literature and we took a look at some case studies. Then we concluded that it is possible. If some people can do it, others can do it as well. And there was nothing inherent in some of the concepts which would prevent their adoption over a wider range of the United States.

Representative HAMILTON. Are you recommending a major effort to get farmers to adopt these practices and approaches of alternative agriculture?

Mr. PESEK. I have not advocated it. We do have programs in Iowa where we are showing farmers through demonstrations that it is possible for them to have better net incomes by careful application of information than they would if they were left to their own resources in terms of information.

So, yes, anything that improves the environmental sustainability of our landscape, and of our soils, and improves the likely viability of the rural communities and farmers on their land, I would certainly support. Yes, sir.

Representative HAMILTON. Is it your sense generally that alternative agriculture is going to be more profitable then conventional agriculture?

Mr. PESEK. Certain aspects of applying alternative systems are more profitable than some of the others. For example, fertilizing with nitrogen to maximize the profit per acre, instead of the maximum yield, is more profitable. We have evidence collected from three different sources in our State which suggests that the amount of nitrogen that is used is much in excess of what is needed for maximum profit. All that extra nitrogen loses money for the farmer. It costs the economy of the State dollars because we have no oil wells or gas wells, and besides it may lead to problems with groundwater contamination with nitrates.

Representative HAMILTON. What changes do you recommend—maybe you recommend many, but what major changes do you recommend in government agricultural programs now to encourage alternative agriculture?

Mr. PESEK. Well, I did not really recommend any, but the report would imply that we would favor removing the disincentives for people to farm differently than what they have. It is my feeling and I think the feeling of many people—and I think Mr. Ruttan spoke to that a minute ago—that farmers farm in the way they farm because of the rules and laws that govern farming.

Representative HAMILTON. They farm the programs instead of the land?

Mr. PESEK. Well, some people have said that too, yes, sir. In fact, some farmers are reported to say that they make more money doing that than farming corn.

Representative HAMILTON. Are you recommending then specific legislative proposals?

Mr. PESEK. I have not recommended specific legislative proposals.

Representative HAMILTON. When you talk about removing these disincentives, do you have 10 or 12 or 15 disincentives that you want to remove?

Mr. PESEK. To mind come the comments made by dairy farmers in our State who said that they have been protecting the soil with forage-based rotations. They have been protecting the soil. They say they have no grain program that puts a floor under their ability or success in producing grain. With tongue in cheek, I ask them about the milk program they have, and they choose to forget or ignore the point.

But if a farmer could produce products differently and not be penalized in the long run, then I think it would be helpful. For example, if soybeans could be grown on corn allotment acreage without penalty, I think that we might have a better supply of soybeans and less of an oversupply of corn at the present time.

So, there are a lot of these things that I conceive as being possible. I have to leave it to Congress to decide which are feasible. I do not see us turning agriculture over completely within a few years. I think it has to be a long-term process. We got to this point slowly, and I think we can retrench slowly. And I am convinced that we do have to continue to pay more attention to the preservation of the soil resource itself.

Representative HAMILTON. In any event, the board's objectives were not to present legislative recommendations with respect to farm programs in America.

Mr. PESEK. I would let Mr. Goodman answer that. I think he was a member of the board at the time we were commissioned.

Mr. GOODMAN. Actually I was not, John. [Laughter.]

Mr. BENBROOK. Mr. Chairman, the report issues a series of recommendations for both reform in commodity polices and conservation policies, regulatory and marketing policies. And the basic theme in the recommendations, which are not specific legislative language, but rather set out a set of principles and criteria by which our agricultural programs and policies should be evaluated. And we do specifically call for in the report in the 1990 farm bill that the current economic disincentives to producers with corn or other commodity program base acreages who wish to go to rotations, in order to capture the agronomic and biological benefits of them, should be able to do so without in effect giving up the third of their gross farm income that has been coming during the 1980's from the Government.

Representative HAMILTON. Do you agree or disagree with that, Mr. Miller?

Mr. MILLER. I have no problem with it.

Representative HAMILTON. You agree. We are all in agreement. Go ahead.

Mr. HAYS. I don't know whether I agree with it completely. It seems to me when we say remove the disincentives, another way to express it is to remove the incentives on other commodities. In other words, the dairyman is complaining because he does not get the support price on the corn that he grows, whereas the grain producer does get that support price. So, it seems to me that maybe when you say remove the disincentives, you are saying remove the incentives for the base crops.

Mr. BENBROOK. I do not really think that that is right. As all Members of Congress know, it is a very tricky business recutting the share of Federal subsidies that go to different commodities. I think that it is possible—and the report calls for some very simple, practical changes in a range of programs. I would not characterize them as radical reforms or major changes either in the direction of our agricultural policy or in the structure of the programs.

Rather, we advocate and the administration in its flexibility proposal cited the recommendations in this report as yet another reason why providing producers with greater flexibility to manage their farms in ways that make sense, given the natural resources they have to work with and the biological cycles and interactions that occur on the farm, makes good sense. It makes good sense for the farmer, and it makes good sense for the environment.

We identified in the report several instances where we believe that past policies and policies that are still in place provide a barrier to that, and with some modest changes, those barriers could begin to be reduced.

Representative HAMILTON. Mr. Benbrook, you view yourself as kind of an advocate on these matters encouraging farmers to make these changes. Is that fair?

Mr. BENBROOK. Yes, I think that farmers should use inputs sufficiently.

The board is very concerned about trying to provide assistance to the institution to conserve agriculture, the Department of Agriculture land-grant universities with guidance on matters of research policy and other issues that will help our entire country move in the directions toward the goals that we all share. We are an advocate for the kinds of recommendations and the achievement of the kinds of goals that are laid out in the report, but we are not an advocate for some philosophy of farming. We certainly, though, believe that farmers should use available information and sound principles in managing a farm.

Representative HAMILTON. Does that give you any problem, Mr. Miller?

Mr. MILLER. No, not at all. I simply come back to an original comment where we are very concerned in the experiment station, when we make a recommendation for a new technology, that we have at least 3 or 4 years or more behind that base in several locations. And the concern I think that some of us have is that while we certainly espouse and agree with many of the principles laid out in this report, we feel that some of those packages are not yet packaged in technological units for adoption. And we would be very concerned to put out recommendations on some things and say this is the way it ought to modeled across all 400 million acres of cropland in this country.

We are not saying that the report is saying that, but it comes back to this philosophic concept. Many of those principles are already out there—those technologies. But many of the packages we feel need a great deal more study and evaluation.

Representative HAMILTON. You keep talking about differences in philosophy between you and the board. Spell that out for me a bit.

Mr. MILLER. Again, I come back to the comment in the opening statement where I think the report itself says that many of the practices of what is defined as alternative agriculture and conventional are the same. There is an awful lot of common ground here. The philosophical difference is that, yes the board is recommending a more ecological approach, and certainly we cannot argue with that. I think our concern is that while that ecological approach is a sound philosophy, we are concerned the technological packages to take full advantage of it are not yet fully researched. That is my concern.

Mr. GOODMAN. And the board would agree with that. I think we should be very careful, and you should be acutely aware, as perhaps you are, that there are people practicing on the farm today in some cases successfully—and some of the best cases are probably not in the case studies in the report—what the committee would call alternative agriculture, and they are driven by a philosophical orientation. To say that those people have a philosophical reason for doing what they are doing and to take account of the success of what they are doing and to try to understand it better scientifically so that it can be more broadly understood are two different things. And it is the latter that the committee was doing, asking that question and coming up, we thought, with some interesting answers that deserved broader attention and exactly the kind of dialog that is taking place here this morning and about the report in other forums.

Representative HAMILTON. What is the impact on American agriculture as we know it of what you are advocating? What are the implications of it with regard to the quality of food, with regard to the price of food, with regard to safety of food, the structure of agriculture in the country? What kind of impacts do you see?

Mr. GOODMAN. If I can be presumptuous enough to speak to what I think the board's consensus would be on this point, we are not advocating anything of the sort, of a retreat from quality or a retreat from safety or a retreat from the overall productivity of our agricultural production system. And we do not think that it is wise or necessary to retreat at all from those issues of quality.

The issue here is not one of what our objective is, but it is a matter of degree and a matter of approach to achieving the goal that we all have in mind and have in view.

Representative HAMILTON. So, you do not really see major structural changes in American agriculture and alternative agriculture?

Mr. GOODMAN. Not radical and sudden, but over the period of the next couple of decades with the right research agenda and with the flexibility on farms. I call your attention again to the fact that a lot of what we cite and is out there for study is initiatives taken by growers themselves that we can have a steady progress in improving the performance of agriculture both economically and environmentally.

Representative HAMILTON. Well, spell it out for me. What do you see 10, 20 years down the road? If alternative agricultural practices become widespread among American farmers, what are the implications of that in terms of structure, price, environment, and all the rest of it?

Mr. GOODMAN. A really tough question.

Representative HAMILTON. Well, I am aware it is easier to ask than to answer. I appreciate that, but you are the experts in this area. You are the folks that have thought about it. You do not want to be advocating changes if you do not know where they are heading?

Mr. RUTTAN. Could I try?

Representative **Hamilton**. Yes.

Mr. **Ruttan**. It seems to me it is partly a matter of how we implement the process. If we move it at the pace at which it is economically viable, then I do not see major structural changes or major losses in competitiveness or substantially higher prices. We would expect over time to see some locational changes, as Chuck Benbrook has mentioned, in the location of beef feeding, in the location of the dairy industry, in the location of cotton production, and perhaps in several other areas. But if we attempt to mandate the changes more rapidly than the technology becomes available and becomes economically viable, then we could impose some penalties both on consumers and on the structure of agriculture that would be harmful.

Representative **Hamilton**. Is there any suggestion in your report that you are going to mandate changes?

Mr. **Benbrook**. No.

Mr. Chairman, I might take a stab at your question about how would American agriculture look different in 30 years.

You would be hard pressed driving down any rural road 30 years from now to really see much difference. The biggest difference might be in the color of the tractors, and they would be coming from overseas.

But in terms of the information and the principles and the concepts that the farmer is using each year in making key management decisions, those should be much more sophisticated and hopefully effective in bringing about this balance that Senator Symms talked about earlier as what everyone's goal is.

I would not expect that scientists in Iowa are going to be saying in 30 years that a third of the nitrogen fertilizer applied brought about no increase in yields. Yet, that is the current situation.

I would expect to see on most of our highly erodible lands adequate soil cover and a longer term rotation that brings erosion, if not to the so-called tolerable limit, then closer to it. We have made tremendous progress in this country in the last 30 years in bringing soil erosion under control. We have a ways to go. I think that that is one of the environmental production problems that we will make substantial additional progress in the next 30 years. So, you will not see so much bare ground. Bare ground is exposed to rainfall and it erodes. So, you will see more cover, more use of cover crops. You will see more forages introduced in 3- or 4- or 5-year rotations, corn, soybeans, corn, a small grain, and a meadow instead of just corn, soybeans. But unless you have an indepth knowledge of the year-to-year management of the farm, not a lot will look different.

Representative **Hamilton**. How about quality of food, cost of food, exports, safety of food? How about those things?

Mr. **Benbrook**. Well, I think that there is no way that the American public or the farmers in this country are going to accept or allow a significant reduction in the quality of food. I would hope that it would go up. The opportunity to produce——

Representative Hamilton. If alternative practices are put into effect, is it your prediction the quality of food would improve?

Mr. **Benbrook**. In some cases, I think so, yes.

Representative HAMILTON. The environmental damage would be less?

Mr. BENBROOK. In some instances, yes. Certainly we are seeing great progress made in Iowa with——

Representative HAMILTON. Or fewer farmers on the farm.

Mr. BENBROOK. The number of farmers on the land is an outcome of a whole host of social, economic, and policy decisions. Whether alternative agriculture is——

Representative HAMILTON. Does it affect that?

Mr. BENBROOK. It will be perhaps a very small, marginal impact, but it is certainly not going to be a driving force.

Representative HAMILTON. Do you see any impact on farm income?

Mr. BENBROOK. Well, I think for some producers, yes. If Congressman Jontz' bill were passed, corn-soybean farmers who now feel locked out of the opportunity to include forages in their operations and hence have a 1,000-head beef feed lot—if they had the opportunity to grow forages on their feed grain base acres and not give up their deficiency payments, they are going to be better off, and you will see some shift back to the North of some beef feeding activity. So, I think that there will be some farmers that benefit from an elimination of some of these policy barriers.

Representative HAMILTON. I will go to Senator Symms here in just a moment, but going back to the definition that you set out in our universities today—you are all senior research people in our universities—are we in agricultural research today moving in these directions so that the manner in which the board has defined alternative agriculture is being encouraged by research that is now going on in our major agricultural research institutions?

Mr. GOODMAN. To speak, to begin with, to the question of the research that is being done in genetics both in the public and the private sector, I would say absolutely, yes. There is a substantial increase in our understanding and, in fact, field trials underway in the field, some of it derived from what my friend and colleague, Mr. Ruttan, would refer to as biotechnology in the field today testing alternative pathogen control, technologies using advanced genetics. There is a very strong component of research in better understanding plant development, reproductive biology, a whole range of science that is being directed toward research, increased genetic technology that addresses directly the agenda of alternative agriculture as spelled out in the report.

Representative HAMILTON. You are suggesting to me a lot of major research now is being done in our agricultural research institutions in the direction of Alternative Agriculture.

Mr. GOODMAN. Your question I took to mean is work being done in our agricultural research institutions headed in this direction, and my answer was yes. A lot, a substantial, a preponderance, enough? No, probably not to any of those. But I think we are headed in that direction, and I think the agenda, in part perhaps influenced by the report, but also the general trends that have been noticeable in American agriculture over the——

Representative HAMILTON. Is that the impression of the other group?

Mr. **Pesek**. Thanks to initiatives in Iowa, we have a major molecular biology thrust that we did not have 6 years ago. In addition, we have a major thrust in the Leopold Center for Sustainable Agriculture which really addresses very directly the issues of alternative agriculture—and the faculty in the university and other people in the State are doing research along the lines of alternative agriculture that we proposed.

Representative **Hamilton**. How about these other institutions? Ohio State, Kentucky, and Minnesota?

Mr. **Miller**. I would comment, yes, we are doing research. Are we doing enough? I think I can emphatically say no, and I can tell you I think why. Researchers will go where the funding is, and if there are incentives out there, it will be done. I think if you sit those people down and have them design their own funding, I think you would certainly see an overwhelming choice to go to more ecological type research, but you have to be out there and put the incentives out there for them to do it.

Representative **Hamilton**. And that money you are talking about largely comes from the Federal Government?

Mr. **Miller**. Yes, that is correct.

Mr. **Hays**. I think Kentucky is no exception to that. Certainly we are doing things in this area. Minimum tillage or no tillage and so forth has been mentioned several times possibly in terms of being alternative. This started really in Kentucky—or a large part of it did—more as a result of the crunch on energy costs than maybe the drive of alternative agriculture. But those types of things are an ongoing part of agriculture research at the present time.

Mr. **Ruttan**. I would like to express a more negative perspective. As you know, Federal research, including agricultural research, is in bad shape. The salary structure is such that you cannot move as a full professor from a university to the Federal level. In addition to that, the Federal science man-years has declined since the mid-1906's. Between the mid-1960's and the early 1980's, that was made up by increases at the State level. Since Gramm-Rudman and the new federalism, more stuff is being pushed down to the States. There is more competition, and State budgets on the average for research have not gone up.

Now we are asking for a broadened agenda. That means if you are going to do the broadened agenda, you are going to take it out of someplace else. And my sense is that we are letting, to some degree, our national agricultural research system atrophy a bit.

Let me make another negative statement. Our constituencies in the Congress and in the States and in the interest groups have some resistance to shifting the research budget. And they are fairly effective at that, but they are not effective enough to expand the budget. So, we are caught in somewhat of a trap, caught by our constituencies and by the lack of support outside of those constituencies.

I am not in research administration. I think I can be a little franker than some of the people who have to defend it. I have been looking at this now for a number of years, and I am concerned. And I am more concerned about Federal research than I am State research.

Mr. **Goodman**. Could I just say, Mr. Chairman, that the board is also and likewise concerned as Mr. Ruttan is. And I just for the record and for your attention call your attention to the Investing in Research proposal which the board released last fall and which Bob Thompson, dean at Purdue, and I had the pleasure of testifying before another Joint Committee hearing in October presenting this report. And it at least, in part, addresses the concern about the infrastructure and the fabric of our research institutions and Federal and State agriculture research.

Representative **Hamilton**. Thank you very much.

Senator Symms.

Senator **Symms**. Thank you very much, Mr. Chairman.

I want to thank all of you. I think this has been a very enlightening hearing this morning.

I want to ask one kind of a general question, and you may just comment yes or no. The chairman was talking about the specifics of the money. Now, we have a problem here, as you know, with the Federal budget. Some of the advocacy groups have advocated that we put as much as $150 million into alternative agriculture. One of you was making comments if the incentives were there, well, then there would be more Alternative Agriculture research within the framework of the land-grant institutions as it is carried on today.

How do you advocate this research dollar be handled from Congress? Just continue to send what moneys that we can find available to the Agricultural Research Service and go through the land-grant institutions and the Agricultural Research Service as it is now done with just the recognition that alternative agriculture is a viable alternative in some cases?

My fear is that Congress would intervene on this, and they might write something into the legislation that says that you cannot use modern technology. I think what I advocated with integrated pest management is an Alternative Agriculture, but nobody is denying the use of this modern technology. Would you recommend that?

If $150 million went for alternative research and then you had $150 million less for the standard research, where does that leave our experiment stations, say, in my State and the other States?

Mr. **Pesek**. I have a bias because I am an experiment station person. I was glad that Mr. Ruttan looked behind the question previously.

There is something good to be said about the formula funding that has served the country very well and which has undergone some neglect in recent years in favor of competitive grants. I think both have their place because without a good research institution in agriculture, one will not get good proposals for competitive grants. So, I think the two have to go hand in hand.

Our report suggested at this point the $40 million for competitive grants. I did not file a minority report. I guess I would have liked to have seen something said about maintaining the base institutions, but I didn't. But $40 million certainly is not excessive in terms of competitive grants. This can be handled quite well by the Cooperative State Research and the Agricultural Research Service systems.

Mr. **Goodman**. In the Investing in Research proposal, we specifically addressed that question by saying that the competitive grants mechanism—and we cite a series of examples and arguments for why the competitive research grants to accomplish the objectives of the Investing in Research proposal are strong, but we also very clearly state that this should not be at the expense of the existing infrastructure, that the existing infrastructure, if anything, needs to be further strengthened and needs to be maintained because if the basic research that comes out of the Investing in Research initiative is successful, the existing applied and technology transfer capabilities of the land-grant and formula-funded system is going to be absolutely necessary for effective utilization in American agriculture.

Senator **Symms**. Mr. Miller.

Mr. **Miller**. I have read the Investing in Research report and support it wholeheartedly. I can clearly understand the concern you have about where do you get it. But I think they have done an excellent job in making the tradeoffs.

And I would be very emphatic to say that I am very concerned that we not give much allegiance to those who are advocating, well, let's put it here and take it away over there. I do think that that would be disastrous for the agricultural research system.

Senator **Symms**. Just one other question, or maybe two, I would like to direct to any of the panelists. I know there is quite an advocacy in the report for using more animal manures in replacement of commercial fertilizer. But what is the risk of coliform contamination in the water supply if we did, in fact, go to that method? Or are we using most of the animal manures now that are available already in cropping in general, putting them back out on the field?

Mr. **Hays**. We are using most of the manures at the present time, going back onto the land. There is risk of coliform contamination. That is primarily the result of runoff and carrying with it the bacterial population of the manures. So, the things that we need to do is increase our efforts for controlling pollution.

Senator **Symms**. Unless we get a lot more animals than we now have, that problem is not going to be any greater or less great than it already is?

Mr. **Hays**. That problem is not going to change appreciably.

Senator **Symms**. In other words, no matter what we do, most of that is now being used. Do you all agree with that?

Mr. **Hays**. We were talking earlier and, as Mr. Ruttan said, it has been a long-term policy to not put your well downstream from the feed lot. And that is the way you get around the coliform problem is watch where that runoff is going and controlling the runoff.

Mr. **Pesek**. And we need to be sure that our wells are well constructed. The contamination from coliform in Iowa frequently is in shallow wells, and there is underway a study to determine what is the condition of the casing and the construction of those wells. I suspect that they will be found wanting when we get done with that study.

Mr. **Benbrook**. Senator Symms, I would simply add that manure is just like nitrogen. It is an input into the crop production process. It needs to be managed well. As Mr. Hays pointed out, with commercial fertilizer, it is stable. You pull out an anhydrous tank and you know what you got, or a urea-based formulation you can prescribe very carefully.

But it is not beyond the current technological capabilities of American agriculture to test the nutrient content of manure. About half the dairy farms in the country have installed and virtually all the hog confinement operations now have installed very sophisticated slurry manure collection systems where the nitrogen, potassium,. phosphorus content of the manure is reasonably well preserved. And with modern technology and good management, manure can be used as a profitable input to a crop production system from a livestock system.

And that is the goal. It is not that we want to get Americans to eat more Big Macs so we have more manure to go, but that the resources that we have ought to be utilized in a way that its economic value is fully exploited so that it does not become an environmental problem.

And the basic point of alternative agriculture is that if you treat manure as a waste and take your manure spreader out every day all winter long and put manure out on frozen ground, you are going to have a lot of runoff and you are going to get very little economic return from the manure in the form of corn the next year.

Here is an opportunity to advance the economic and the environmental performance of American agriculture. And we merely recommend and hope that more of those opportunities will be exploited.

Senator Symms. I think you all basically agree with that. That is part of what we have been trying to accomplish for the last 100 years or so.

Mr. Pesek. While we have been successful, we have not been completely successful.

Senator Symms. No, but it makes sense and eventually it should become a practical process.

I will just ask one last question, and that is just with respect to the toxicology question. This was touched on slightly by Mr. Lee, but any of you can comment on this.

Several of the CAST reviewers have pointed out that natural toxins posed a much greater risk of food safety than pesticide residue, and that lowering inspection standards to allow more blemished fruits and vegetables could present greater risk for entry of pathogens. I think I heard one of you earlier say that you were against lowering the standards. Mr. Goodman I think said that.

But what assurance do we have that the American consumers are willing to face these food safety risks or even that facing such risk is necessary? I guess my complaint is the potential for risk overstatement that often happens to American agriculture. Somehow pesticide residues, when they are measured in such minute parts as parts per billion or even in very small parts per trillion, and into the parts per quadrillion, almost irrelevant, but yet it makes great headlines in the newspapers.

Would any of you want to comment on that?

Mr. Hays. I would comment on it. Mr. Bruce Ames has talked about this, and he is the granddaddy of the Ames test for carcinogenicity or mutagenicity. And as he points out, if you just look at the total intake of toxic materials that a person takes in a day, we take in far more than in the natural foodstuffs than we do as pesticide residues or herbicide residues and so forth.

It is the dosage level or the amount that you take in that is the crucial point. If we allow some of the fruits and vegetables and so forth to be damaged by insects, this does allow for aflatoxin invasion or the fungus invasion, which the aflatoxins are some of our most potent carcinogens.

So, this is a concern. We talk about the cosmetic effects of some of the things that we do for fruit and vegetables, but there are some beneficial effects as a result of that too. If you damage a potato, which you are very familiar with, you will often notice a black fungus invasion there, and we really have not tested the impact of all of those on the fruit and vegetables that we are eating.

Senator SYMMS. Thank you very much. Gentlemen, I appreciate all of your efforts to be here today. And, Mr. Chairman, I want to thank you again for having this hearing.

Representative HAMILTON. Thank you very much, Senator Symms.

I think we have had a good and productive hearing. My thanks to the panel as well. It has been a productive discussion.

And we stand adjourned.

[Whereupon, at 12:07 p.m., the committee adjourned, subject to the call of the Chair.]

○